Vol. 20, No. 2, Journal, pp. 31-66

THE JOURNAL and CERAMIC ABSTRACTS, FEBRUARY, 1937

16—2, Ceramic Abstracts, pp. 53-78

THE JOURNAL and CERAMIC ABSTRACTS

AMERICAN CERAMIC SOCIETY

MARCH • 1937

MONTHLY PUBLICATION DEVOTED TO THE ARTS AND SCIENCES RELATED TO THE SILICATE INDUSTRIES

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Entered as second-class matter at the post office at Easton, Pa., under the act of March 3, 1879. Published monthly.
Subscription fifteen dollars ($15.00) a year. Single numbers $1.50
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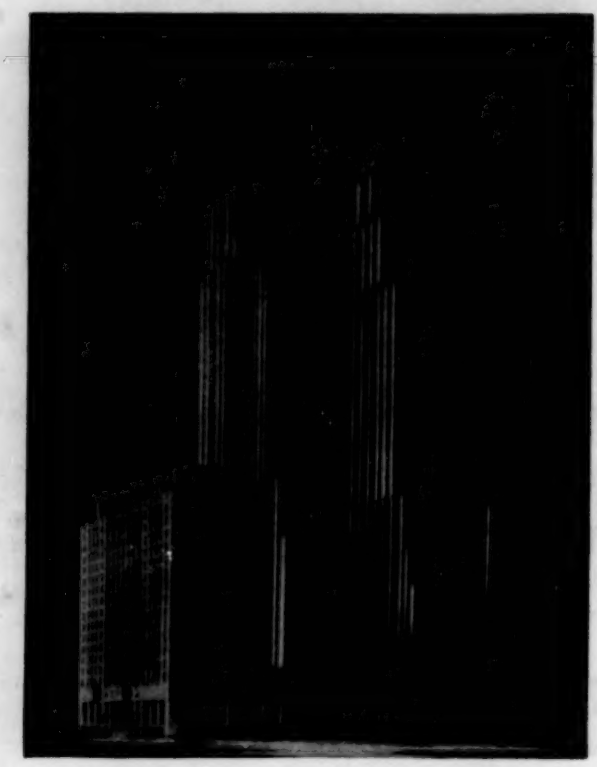

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COLOR MEASUREMENTS*

By J. L. Michaelson

Abstract

There is a growing need in the enamel industry for accurate specification of color. This paper is a discussion of the objective method of color specification and instruments for measuring color.

I. Introduction

The combining, mixing, and blending of colors to produce a pleasing effect is an art. The duplication and control in mass production should be a science. In view of the facts (*a*) that a color stimulus is usually of a compound nature consisting of a mixture of radiant energy of different wave-lengths and amounts, (*b*) that the human eye is nonuniformly sensitive over the whole spectral range, and (*c*) that fatigue and external illumination conditions influence color perception, observations by eye are naturally not dependable.

The reproduction of art creations has been a rule-of-thumb procedure based largely upon the experience and intuition of the workman. While this method has produced remarkably good results in spite of the adverse conditions of color perception, it nevertheless leaves much to be desired from a practical and scientific point of view.

The discovery and development of new coloring media combined with the progressive merchandising methods of the last few years has increased the need for a scientific technique of handling the color problem.

II. Nomenclature

In addition to the complexity of the subject, the nomenclature used in discussing color has been in an undesirable state. Such terms as shade, hue, chroma, saturation, value, brilliance, tint, etc., are largely misused by those interested in the art. Various attempts have been made to clarify this condition; one notable example was the Munsell system of color notation which set out to classify all colors with respect to their psychological attributes, *i.e.*, hue, brilliance, and saturation. These terms have been defined[1] as follows by the Colorimetry Committee of the Optical Society of America:

(1) *Brilliance* is that attribute of any color in respect of which it may be classified as equivalent to some member of a series of grays ranging between black and white.

(2) *Hue* is that attribute of certain colors in respect of which they differ characteristically from the gray of the same brilliance and which permits them to be classified as reddish, yellowish, greenish, or bluish.

(3) *Saturation* is that attribute of all colors possessing a hue, which determines their degree of difference from a gray of the same brilliance.

III. Nature of Color

The nature of color can be specified psychologically in terms of these three attributes but without any reference whatsoever to the stimulus. Such a specification alone is of little value in scientific work.

Contrasted with this is the objective method which specifies the stimulus responsible for color. A simple experiment may be imagined which will illustrate the objective method of color specification.

Ordinary daylight and Mazda light are composed of radiations extending throughout the visible spectrum. It is possible to separate these radiations from each other by employing a prism (see Fig. 1). If these spectral radiations, separated by the prism, are allowed to fall upon a magnesium-carbonate block, all spectral hues will be reflected quite well. Such a material is broadly classified as white. When a black velvet cloth is substituted for the magnesium-carbonate block, it is observed that a very small proportion of these spectral radiations is reflected. A neutral gray paper, if illuminated by this spectrum, will exhibit a reflecting ability for all parts of it which is greater than that for the black but less than that for the white. Similarly a light gray paper will reflect more than a dark gray. All of these samples, it can be observed, exhibit nonselective reflection; that is, they reflect uniformly all parts of the visible

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, April 1, 1936 (Enamel Division). Received April 13, 1936.

[1] L. T. Troland, "Report of Committee on Colorimetry for 1920–21," *Jour. Optical Soc. Amer.*, (p. 543), **6** [8] 527–96 (1922); *Ceram. Abs.*, **2** [1] 8 (1923).

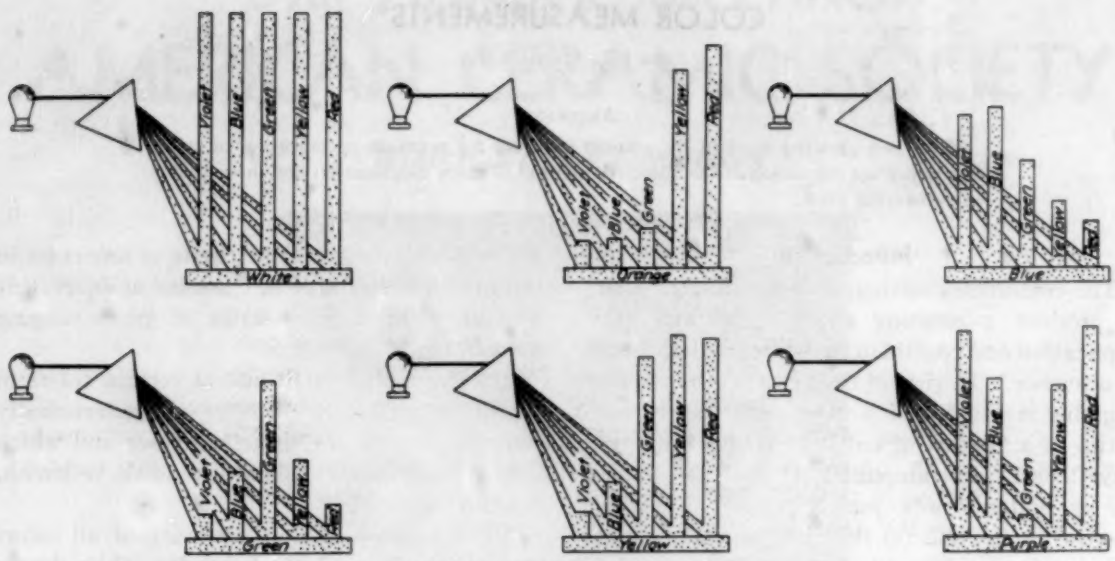

FIG. 1.—Spectral reflectance.

spectrum. The ratio of reflected light to incident light is the reflectance.

If a colored sample, for instance an orange sample, is illuminated by this spectrum, it will be apparent that this material possesses a low reflectance in the violet, blue, and green parts of the spectrum, but a high reflectance in the orange and red. A dark orange sample will exhibit similar absorption in the violet, blue, and green and a lower reflectance in the orange and red. A green card will illustrate that the general property of green is to reflect the green part of the spectrum and absorb the blue and red. Likewise, a bright blue sample will effectively reflect the blue and absorb the orange and red. A dark blue will again exhibit similar absorption in the red and orange with a decrease in the blue reflectance. Thus, it follows that a means of measuring the degree of selective spectral reflectance of a colored material would afford an objective specification of that color. Instruments devised to do this are known as spectrophotometers. It is generally recognized that spectrophotometry is the only fundamental method of color specification. Samples which are alike spectrophotometrically are a color match under all conditions of illumination, and to all observers, even if the observer be color blind. The difficulties encountered and the time consumed in making spectrophotometric measurements have, however, considerably retarded the general adoption of this method of color specification, and have, on the other hand, been largely responsible for the so-called short-cut methods of colorimetry as illustrated by a variety of colorimeters and reflection meters which have been offered to the public during the last few years.

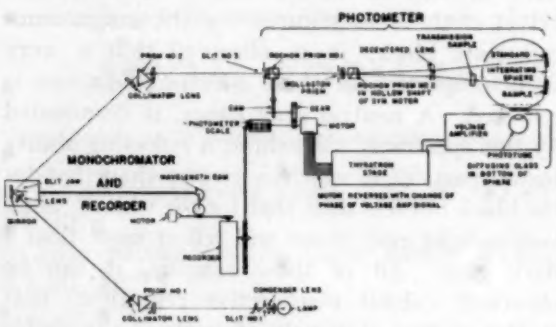

FIG. 2.

The difficulties encountered with visual spectrophotometers have caused various attempts to be made to employ phototubes as a substitute for the eye. This substitution, however, does not in itself guarantee that difficulties and errors will be eliminated, for phototubes like eyes have characteristics and defects which must be recognized if they are to be used to the best advantage. Nevertheless, it is possible to employ photoelectric methods in spectrophotometry with more convenience, quicker measurements, and greater precision.

IV. Recording Spectrophotometer

The recording spectrophotometer, invented by Hardy[2] at the Massachusetts Institute of Technology and developed for commercial application by the General Electric Company, is an example of this type. This device consists essentially of a double-prism monochromator, photoelectric photometer, and means of recording graphically their respective values.

Referring to the schematic diagram, Fig. 2, the light from a tungsten-filament light source is dispersed by prism No. 1 to form a spectrum in the plane perpendicular to the mirror at slit No. 2. The portion of this spectrum which passes between the mirror and slit jaw is refracted by prism No. 2 to slit No. 3.

The presence of the second prism also removes any heterogeneous light which may have become mixed with the desired spectral band. The position of the mirror and slit jaw then determines the wave-length of the light at slit No. 3. All slits are operated by cams to maintain a constant wave-length band of 10 millimicrons.

Monochromatic light from slit No. 3 is plane-polarized by Rochon prism No. 1. The Wollaston prism generates two components, mutually perpendicularly polarized, which fall upon sample and standard, respectively. Rochon prism No. 1 is mounted in a bearing and is rotated by a cam arrangement. The angular position of this Rochon, with respect to the Wollaston prism, determines the ratio of intensity distribution in the two beams and hence, as will be seen later, is a measure of the reflectance of the sample in terms of the standard. Rochon prism No. 2 is mounted in the hollow shaft of a synchronous motor. The rotation of this element serves to vary the light intensity of the incident beams from maximum to zero on the sample and standard out of phase with each other. A phototube views the frosted glass in the integrating sphere wall, the brightness of which is proportional to the sum of the product of beam intensity and reflectance for both sample and standard. When the light reflected from the sample and standard is not equal, an alternating current component is present in the phototube current. The phase of this alternating component with respect to the voltage applied to the synchronous motor determines which of the two reflected beams is the more intense. This alternating component is then amplified and used to control the direction of the rotation of the balance motor which readjusts the Rochon prism No. 1 to obtain a redistribution of energy in sample and standard beams, thus removing the alternating component in the phototube current. The angular position of this Rochon prism is then a measure of the reflectance of the sample in terms of the standard. As the recording drum revolves, the mirror position is changed by a cam causing a change in wave-length of light incident on the sample and standard. The corresponding change in reflectance of the sample is then automatically measured and plotted upon the chart to produce a complete spectrophotometric curve in $2^1/_2$ minutes.

Transmission measurements are made by using similar samples in the reflectance and standard positions and introducing the transmission specimen in the sample beam.

The illumination on the sample and standard is normal to the surface and covers a portion one inch in diameter. The frosted glass in the sphere wall is symmetrically located with respect to the sample and standard.

Thus, owing to the nature of the optical system, this instrument evaluates the amount of light that is diffusely reflected by an opaque material when illuminated by a nearly unidirectional beam falling normally on the surface.

The light on the sample and standard is derived from the same source, thus eliminating the characteristics of the source. The optical system, furthermore, is common for both sample and standard with the exception of a pair of decentered lenses, which are actually made from the same lens. Since the amplifier functions only when the instrument is unbalanced, the characteristics of this unit do not influence the measurement. Inasmuch as only monochromatic light reaches the phototube, its spectral response characteristic does not enter into the result.

A tangent[2] relationship exists between the angle of the Rochon prism No. 1 and the reflectance scale, and a cam is used to obtain this relationship. Special cams are interchangeable with the regular cam to plot special functions of reflectance of transmission. One such cam makes it possible to plot optical density directly. Another cam can be made to plot log-log reflectance or log-log transmission as a function of wave-

[2] A. C. Hardy, "A New Recording Spectrophotometer," *Jour. Optical Soc. Amer.*, **25** [9] 305–11 (1935).

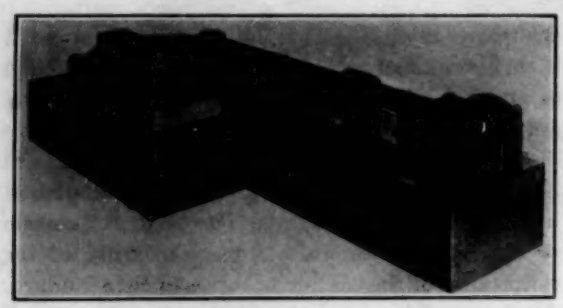

FIG. 3.—Recording photoelectric spectrophotometer.

length, which is useful in studying materials of unknown thickness and unknown concentration. If a material obeys Beers' law,[3] the shape of the curve obtained with this cam is independent of thickness or concentration, and the curve is merely shifted vertically on the sheet with variations in thickness or concentration. For instance, this cam can be used to identify colored glasses of different thicknesses.

Figure 3 is a photograph of the complete instrument. The optical parts are inclosed, thus protecting them from dirt, etc. The recorder is located in a convenient position and two speeds of recording are available, $2^1/_2$ or 5 minutes, depending upon the requirements of the user.

V. Spectrophotometric Measurements

(1) Red

Figure 4 is a spectrophotometric measurement of a highly saturated red sample. The reflectance scale is divided into $^1/_2\%$ divisions. The precision of the instrument is about 0.1% full scale, which is approximately 10 times that of the eye.

(2) Blue

Figure 5 represents a similar measurement on a blue sample which may be very slightly purple as shown by the presence of some red.

The curve of Fig. 6 illustrates a characteristic of many green samples, *i.e.*, to reflect considerable red light.

(3) Yellow

Yellow, in Fig. 7, is of interest because of the almost complete absorption of the blue and violet.

(4) Purple

Figure 8 has similar characteristics to the blue of Fig. 5; more red light is reflected in this sample and the result is purple.

It can be observed from these curves that the psychological attributes of color mentioned earlier correlate somewhat with the shape of these curves.

VI. Evaluation of Brilliance

Brilliance of the sample is influenced greatly by its reflectance at 550 millimicrons. A better evaluation of brilliance may be obtained from this spectrophotometric data by multiplying these data by the standard visibility function[4] of the eye and integrating the area under the resulting curve.

VII. Evaluation of Hue

The hue depends upon the position of the curve with respect to the wave-length scale and is commonly estimated by dominant wave-length. The dominant wave-length may be determined

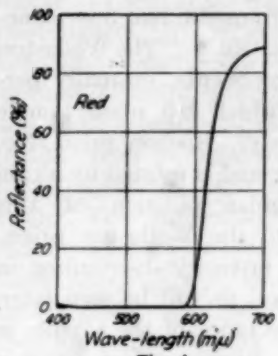

Fig. 4

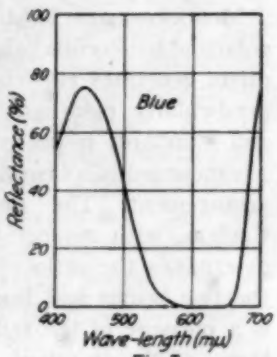

Fig. 5

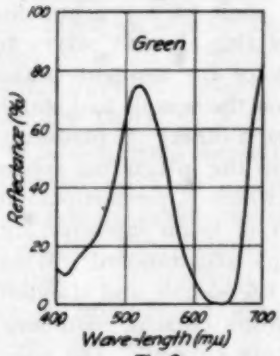

Fig. 6

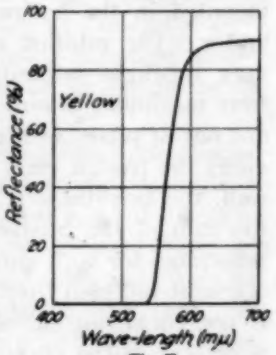

Fig. 7

FIGS. 4–7.

[3] Beers' law:

$$T = e^{-acx}$$

T = transmission.
a = absorption coefficient.
x = thickness.
c = concentration.

[4] D. B. Judd, "I. C. I. Standard Observer and Coördinate System for Colorimetry (1931)," *Jour. Optical Soc. Amer.*, **23** [11] 359–74 (1933); *Ceram. Abs.*, **13** [8] 198 (1934).

by evaluating the spectrophotometric curve in terms of the excitation functions of a standard observer.[4]

The saturation correlates well with the steepness of the curve and with excitation purity which may be evaluated by the excitation functions for a standard observer.[4]

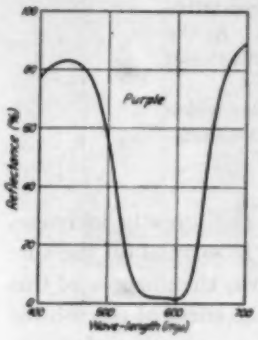

FIG. 8.

VIII. Typical Case Measurements

Two samples which are alike spectrophotometrically appear to match in color to all observers under all conditions of illumination. Two samples may not be identical spectrophotometrically yet appear alike under a particular condition of illumination and observation. Such samples will not remain color-matched if the conditions of illumination and observation are changed. It is always possible to evaluate spectrophotometric data closely in terms of other psychological attributes of color, but it is not possible to reverse this procedure.

Figure 9 illustrates typical measurements of two enamel surfaces which are approximately equal in brilliance but not of the same color. A single measurement of the reflectance at 550 millimicrons would approximately evaluate the brilliance but would not furnish any information regarding the hue or saturation. Sample B is considerably more yellow than sample A. Thus, two samples which may show the same reflectance at 550 millimicrons are not necessarily color-matched.

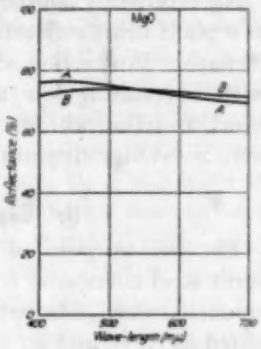

FIG. 9.—Spectrophotometric curves of enamel samples showing equal reflectance at 540 mμ.

(1) Effect of Opacifiers

A set of curves as illustrated in Fig. 10, showing the effect on color of various amounts of opacifier, are extremely useful in studying enamels for color, economy, etc. These curves are for 0, 2, 4, 6, and 8% tin oxide in a standard enamel. It is interesting to note that the hue and saturation as well as the brilliance vary with the percentage of tin oxide.

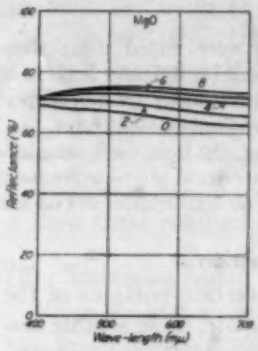

FIG. 10.—Spectrophotometric curves of enamel samples containing 0 to 8% tin oxide.

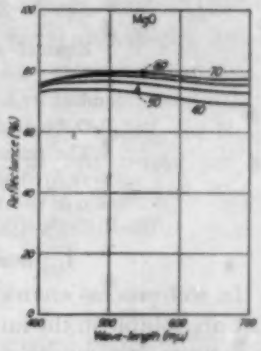

FIG. 11.—Spectrophotometric curves of enamel samples showing the effect of different weights.

(2) Effect of Enamel Thickness

Figure 11 illustrates a similar set of curves except that the thickness of the enamel has been varied from 40 to 70 grams. The study of thickness and color relationships is important in enameling.

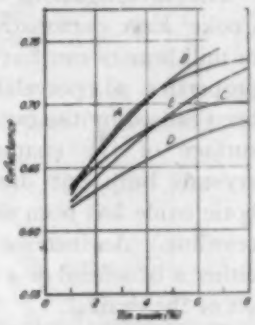

FIG. 12.—Reflectance of enamel samples owing to various amounts of five different tin oxides.

IX. Materials Control Tests

Pertinent information may be obtained regarding the quality of enameling materials of various manufacturers. Figure 12 illustrates the results of making up test panels containing 1 to 8% tin oxide from each of five sources of supply.

It is interesting to note that some oxides were considerably better than others in their effective opacity; 4% of some was as effective as 8% of others. At the present price of tin oxide and the large quantity used, it is easy to see the savings that can be made by such measurements.

GENERAL ENGINEERING LABORATORY
GENERAL ELECTRIC COMPANY
SCHENECTADY, NEW YORK

EFFECT OF SOLUBLE SALTS FORMED DURING AGING ON THE SCUMMING OF ENAMELS*

By R. J. Whitesell

Abstract

Enamel slips were milled using three typical commercial frits. Representative samples were aged for different lengths of time and at varying temperatures. At the end of its individual aging treatment, portions of each sample were filtered, Na_2O and B_2O_3 being determined on all filtrates.

The remaining slip from each sample was then used to spray sample plates which were fired at the critical temperature for the formation of scum on enamel. A correlation of the data on soluble salts and on scumming is made.

I. Introduction

In wet-process enamels, certain portions of the frit are soluble in the mill liquor, these soluble materials having many important effects upon the enamels. Danielson[1] showed that the solubility of frits varies over a wide range, depending upon their compositions, and that the solubility of a frit varies with differences in milling conditions. He also indicated specifically the variations in the Na_2O and B_2O_3 content of mill liquors from enamels ground in small laboratory mills and those ground in large plant mills. Cook[2] reported that the solubility of frits was increased with increased fineness of grinding, with agitation of the milled enamel, and with aging.

The investigations of Danielson,[1] Cook,[2] and Cooke[3] have demonstrated that the soluble salts in mill liquors can have important effects on the properties of porcelain enamels. Pitting has been caused by the crystallization of borax on the surface of the enamel during drying. These crystals burn out during firing. An excess of boric oxide has been shown to cause tearing and crawling. An increase of soluble salts may have either a beneficial or a deleterious effect upon the set of the enamel.

The quantities of these soluble salts, which are predominately compounds of Na_2O and B_2O_3, are small compared with the quantity of frit from which they are leached. During the drying of the enamel, however, most of these salts are carried to the surface and deposited by the evaporation of the water. This action greatly increases the ratio of Na_2O and B_2O_3 to enamel on the surface of the dry bisque. It was the purpose of this investigation to determine the effect of the soluble salts in the mill liquor on the scumming of enamels. This defect is sometimes called "dulling," and the principal cause is firing at too low temperature, which is often found in furnaces that are being operated at peak loads. It is to be understood that this type of scumming is different from that caused by sulfur gases. In the underfire type of scumming, the defect appears on portions of the ware which are in the coldest parts of the furnace.

An excellent example of this trouble was found in a plant firing refrigerator parts in a continuous furnace. Production schedules were very heavy, with a resulting low temperature in the firing zone, and the bottom parts of doors and liners were covered with scum.

II. Experimental

For the purpose of this investigation, three sheet-steel cover-coat frits, typical of present-day enamels, were selected. These frits are designated as A, B, and C.

The frits were ground with 6% Vallendar clay, 5% tin oxide, and 42% water in 1000-gram laboratory mills, to a fineness of 7.7% of the frit on a 200-mesh screen. To insure a uniformity of water content, the specific gravity of each enamel was adjusted to 1.80. The enamels used for the firing trials were fresh milled and aged for 1, 4, 7, and 10 days at different temperatures. For this purpose, after they were prepared, they were stored in air-tight glass containers at temperatures of 32, 70, 100, and 140°F.

(1) Determination of Soluble Salts

On the day when firing trials were made, a por-

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, March 31, 1936 (Enamel Division). Received March 19, 1936.

[1] R. R. Danielson, "Effects of Soluble Salts on the Properties of Enamel," *Jour. Amer. Ceram. Soc.*, **12** [8] 538–47 (1929).

[2] H. L. Cook, "Solubility of Enamel Frit in Mill Water," *ibid.*, **10** [5] 339–43 (1927).

[3] R. D. Cooke, "Study of Soluble Salts in Enamel," *ibid.*, **13** [9] 658–61 (1930).

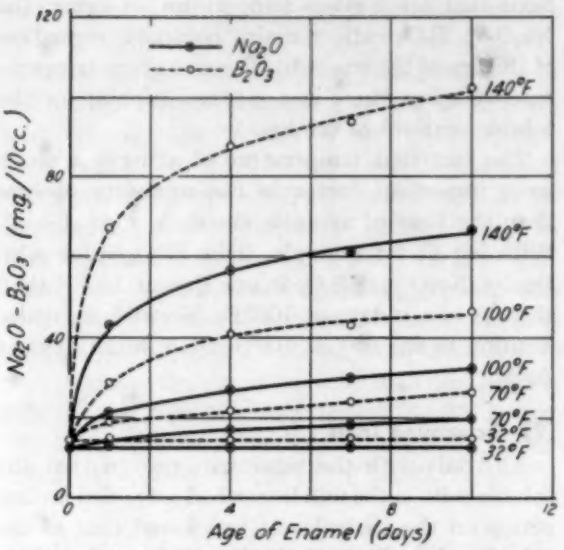

FIG. 1.—Frit A: Effect of time and temperature of aging of enamel on Na_2O and B_2O_3 content of mill liquors.

tion of each sample of enamel was filtered, using a Buchner vacuum filter. By using reasonable care, perfectly clear filtrates were secured. This method was found to be much quicker than centrifuging and more practical under the experimental conditions than allowing the enamels to settle and pipetting the sample of mill liquor.

Total alkalis, calculated as Na_2O and B_2O_3, were determined by titration. While there is no doubt that there are other materials in the mill liquors, the quantities are so small that they can be ignored without affecting the results to any marked degree. To determine the Na_2O content, 10 cubic centimeters of mill liquor were titrated with hydrochloric acid, using methyl orange as an indicator. For the B_2O_3 determination, phenolphthalein was added to the sample used in the Na_2O determination, the CO_2 was taken off under vacuum, 40 cubic centimeters of neutral glycerine were added to form the more highly dissociated boric-acid complex, and the titration was made with NaOH. At the conclusion of the alkali titration, a small excess of acid was added to aid in the removal of CO_2. The equivalent amount of NaOH was subtracted from the boric-acid titration. The boric acid end-point is rather poor but, with a little practice, consistent results were obtained.

A second series of trials was made to check the results obtained above. In the first series of trials, there is possibility of error owing to differences in milling of the various lots of enamel. In the second series, a quantity of each enamel was milled and samples of these enamels were aged for the various times and temperatures as given above. Na_2O and B_2O_3 determinations were made on all samples. A comparison of the results showed that there were only slight differences in the two series. The averages of the Na_2O, B_2O_3, and Na_2O to B_2O_3 ratio determinations from the two series are shown in Table I, the Na_2O and B_2O_3 being reported as milligrams per 10 cubic centimeters of mill liquor. Figures 1, 2, and 3 show these results in a graphical form.

(2) Scumming Trials

From the first series of trials, 17 samples of each frit, 6- by 4-inch ground-coated plates of 20-gage steel, were sprayed at 45 grams per square foot. The plates which were used were of the same weight (±1%), the weight being held within these limits to prevent error, since heavier steel causes an increase of scumming. Care was taken that all plates were sprayed and dried in exactly the same manner. After drying, these plates were fired at a temperature sufficiently low that the edges of the plates showed typical underfire scumming. Every precaution was taken to insure that all plates received the same firing treatment.

III. Results

(1) Soluble Salts

The results of the Na_2O and B_2O_3 determinations disclose many interesting facts about the

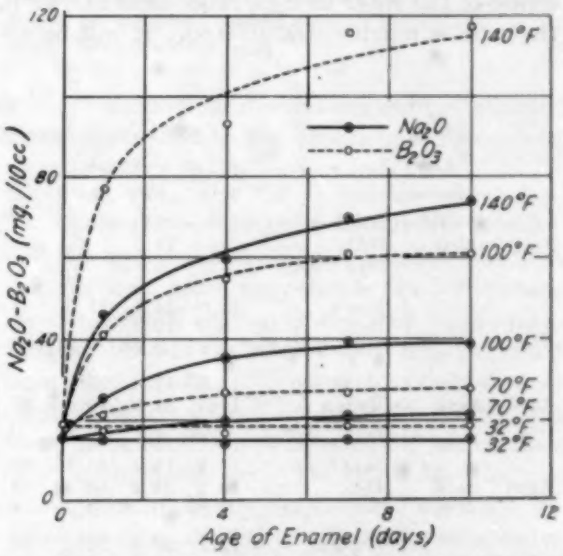

FIG. 2.—Frit B: Effect of time and temperature of aging of enamel on Na_2O and B_2O_3 content of mill liquors.

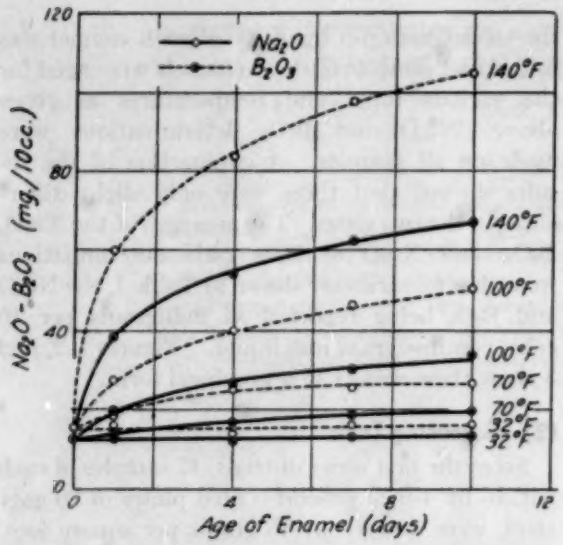

FIG. 3.—Frit C: Effect of time and temperature of aging of enamel on Na_2O and B_2O_3 content of mill liquors.

solubility of frits. With the exception that frit B is somewhat more soluble than frits A or C, the results for all three are, in general, the same (see Table I and Figs. 1 to 3).

At the end of the milling period, the mill liquors contain Na_2O and B_2O_3 in a ratio of 0.80 to 0.85. When the enamel is aged at 32°F, there is practically no solution of the frit, and the Na_2O to B_2O_3 ratio remains constant. With an increased temperature of aging, however, there is a decided solution of the frit, the dissolved B_2O_3 increasing more than the Na_2O, with a corresponding decrease of the Na_2O to B_2O_3 ratio, until at 140°F, the ratio is roughly 0.60 to 0.65. It will be noticed that for a given temperature of aging, the Na_2O to B_2O_3 ratio remains constant, regardless of the age of the enamel. For any given temperature of aging, there is a saturation point for the soluble portions of the frit.

The fact that temperature of aging is a much more important factor in the solubility of frits than the time of aging is shown in Figs. 1 to 3. With frit C, for example, there is a greater solution of Na_2O and B_2O_3 in one day at 140°F than there is in ten days at 100°F; likewise, a greater solution in one day at 100°F than in ten days at 70°F.

(2) Scumming Trials

All trials with the three frits proved that the soluble salts in the mill liquor had a decided fluxing action on the enamel. It was found that as the soluble salt content of the liquors increased there was a decided decrease in scumming. It is to be remembered that, while the actual amount of these salts is low, there is a high concentration of them on the surface of the enamel.

In all cases, the fresh-milled enamel had the greatest amount of scum. Enamels aged at 32°F showed the same scumming tendency as the fresh enamel. With an increase of soluble salts, there was a decided decrease in the scumming, the reduction in scumming being proportional to the amount of soluble salts in the mill liquor. Referring again to Fig. 3 for frit C, the enamel aged one day at 140°F scums less and has a higher Na_2O and B_2O_3 content than the enamel aged ten days at 100°F; likewise, the enamel aged ten days at 70°F scums more and has a lower Na_2O

TABLE I

Na_2O AND B_2O_3 IN MILL LIQUOR (MG./10 CC.)

Aging temperature		Frit A				Frit B				Frit C			
		32°F	70°F	100°F	140°F	32°F	70°F	100°F	140°F	32°F	70°F	100°F	140°F
Fresh milled	Na_2O		12.3				15.7				12.9		
	B_2O_3		14.5				19.2				15.5		
	Na_2O/B_2O_3		0.85				0.82				0.83		
Aged 1 day	Na_2O	13.0	14.6	21.6	43.3	15.0	16.7	25.1	46.2	13.4	14.1	19.8	38.5
	B_2O_3	15.0	19.3	29.1	67.1	17.1	21.2	41.0	77.1	16.1	18.7	27.7	60.1
	Na_2O/B_2O_3	0.87	0.76	0.74	0.65	0.88	0.79	0.61	0.60	0.83	0.75	0.71	0.64
Aged 4 days	Na_2O	12.5	17.3	27.3	56.8	14.1	19.9	35.4	59.8	12.1	17.2	26.9	54.1
	B_2O_3	14.5	21.9	41.0	87.9	16.8	27.0	54.8	93.4	14.2	25.6	40.1	84.1
	Na_2O/B_2O_3	0.86	0.79	0.67	0.65	0.84	0.74	0.65	0.64	0.85	0.67	0.67	0.64
Aged 7 days	Na_2O	12.9	18.4	30.1	61.1	15.5	21.1	39.7	69.7	13.3	18.8	30.3	62.4
	B_2O_3	15.2	24.2	43.3	94.1	18.6	26.8	61.3	116.1	16.6	25.8	46.7	98.1
	Na_2O/B_2O_3	0.85	0.76	0.69	0.65	0.83	0.79	0.65	0.60	0.80	0.73	0.65	0.64
Aged 10 days	Na_2O	12.7	20.0	32.1	66.8	15.5	21.3	39.2	74.0	13.4	19.7	33.8	67.1
	B_2O_3	14.8	26.2	46.6	102.6	18.7	27.9	60.9	117.4	16.7	26.7	50.4	105.2
	Na_2O/B_2O_3	0.86	0.76	0.69	0.65	0.83	0.76	0.64	0.63	0.80	0.77	0.67	0.64

and B_2O_3 content than the enamel aged one day at 100°F.

While an increase of soluble salts has a beneficial action on the scumming of enamels, there were several harmful effects. With all enamels aged at 100° or 140°F there was considerable tearing, this defect increasing rapidly with an increasing soluble salt content. In those enamels with high soluble salts, tearing was extremely bad.

Another harmful action of the soluble salts was their effect on the dry bisque. Those enamels aged at 100° and 140°F dried to an exceedingly hard and brittle bisque, which, with the highest soluble salt content, was impossible to brush. This formation of a hard, brittle bisque aggravated the tearing trouble along brushed edges.

IV. Conclusions

(1) The solubility of typical commercial frits is influenced more by the temperature of aging of the enamel than by the time of aging, the rate of solution being negligible at 32°F and increasing greatly with increased temperatures.

(2) An increase of the soluble salts in the mill liquor produced by aging at a given temperature or by an increase in the temperature of aging, decreases the scumming of an enamel caused by firing at too low temperatures. While the tendency of an enamel to scum no doubt is affected to as great or greater degree by such factors as fineness of grinding, amount of clay, and temperature of firing, under a given set of milling and firing conditions, the soluble salt content of the mill liquor does have an appreciable effect on the scumming. Under normal milling and aging conditions, this change is small; temperatures of 100°F, however, are common in enamel plants during the summer, and temperatures of 140°F and higher are often reached in mills which run hot. With these increased temperatures, a high soluble salt content will be built up in a relatively short period of time, and the degree of the scumming will be greatly decreased.

(3) An increase of soluble salts in the mill liquor increases the tendency of an enamel to tear and, as a result of the formation of hard and brittle bisque, aggravates the tearing in places where the enamel is brushed.

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ADHESION OF ENAMEL TO STEEL PRODUCED BY THE ELECTRODEPOSITION OF $Mo(OH)_3$ ON THE STEEL*

By C. R Amberg, H. D. Prior, and J. C. Richmond

Abstract

It has been found that the deposit of $Mo(OH)_3$, produced when steel is made the cathode in a solution of ammonium molybdate, will cause a white enamel to adhere to steel. A theory is advanced, as a possible explanation, that the deposited coating prevents the formation of excess iron oxide which would weaken the enamel-iron bond.

I. Introduction

The three theories of the adhesion of enamels which have received the greatest acceptance are (1) dendrite, (2) oxide coating, and (3) plating. Each has its points of credence, but each is still in its theoretical development.

II. Effect of Molybdates in the Frit

Molybdenum has such a position in the electromotive series that iron will replace it in solution; it has more than one state of valence, a melting point above the ordinary enameling temperatures, and will not color the enamels. Yet, when sodium or ammonium molybdates were substituted for the ordinary adhesion agents in a ground coat, no satisfactory adherence was indicated.

III. Plating from Ammonium Molybdate Solution

When ammonium-molybdate solution was used and the steel made the cathode of a low-voltage current, a black coating on the steel was formed. This coating was fairly tight when wet, but could be brushed off after drying, much as dried enamel can be brushed. Upon analysis, the coating was found to be $Mo(OH)_3$ or $Mo_2O_3 \cdot 3H_2O$ rather than metallic molybdenum. The most satisfactory coatings for enameling were secured when a 3- by 4-inch specimen of steel was plated for six minutes in a 10% ammonium-molybdate solution to which

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, March 31, 1936 (Enamel Division). Received June 30, 1936.

10% by volume of concentrated ammonium hydroxide had been added. The best voltage under these conditions was three volts and the cathode to anode distance one inch.

IV. Adhesion of Enamel

A ground coat without cobalt, applied over the dried molybdenum-hydroxide coating, adhered firmly to the steel when fired but not quite as well as did the same enamel containing cobalt and applied directly to the steel. The cracking of the enamel during the bending was not as finely spaced as it was in the cobalt enamel, but the enamel showed no tendency to flake off and leave clean steel exposed.

TABLE I

COMPOSITION OF ENAMEL

	No. 1 cobalt enamel	No. 2 experimental enamel
Borax	30	30
Feldspar	30	30
Flint	22	22
Cryolite	3	3
Fluorspar	3	3
Soda ash	8	8
Zinc oxide	2	2
Manganese dioxide	1.5	
Cobalt oxide	0.5	
Mill addition 6% Vallendar clay		

NOTE: Enamel No. 2, of course, was not opaque with the result that the enamel appeared fairly dark because of the dissolved iron oxide in the layer in contact with the metal. With the addition of opacifier to enamel No. 2 blistering was encountered.

V. Possible Cause of Adhesion

$Mo(OH)_3$ coating is believed to act as a control in the development of the oxide layer on the iron.

When $Mo(OH)_3$ is heated in air, it readily oxidizes to yellowish MoO_3. The trioxide melts upon continued heating, the melting point being 795°C (1463°F). It is believed that the preliminary oxidation of the $Mo(OH)_3$ prevents some oxygen from reaching the iron at lower temperatures, allows some oxidation of the iron at intermediate temperatures, and stops further oxidation when the trioxide melts. The molten trioxide is very fluid and doubtless wets the steel surface under the enamel, thus effectively sealing it from further contact with oxygen at temperatures a little under those at which the enamel becomes sufficiently fluid to take over the task of further protection from oxidation. Thus $Mo(OH)_3$ limits the thickness of oxide formed on the steel.

It is recognized that an oxide layer is necessary for the adhesion of enamel. Even cobalt enamels do not adhere when fired in neutral or reducing conditions.

If the oxide layer becomes too thick the enamel is incapable of dissolving the layer completely and of wetting the steel, a condition which results in a mechanically weak porous layer of iron oxide between the enamel and the steel and causes poor adherence. Wetting of the steel by the enamel seems to be one of the essential causes of the adherence.

The intermediate layer of iron-rich glass between the enamel proper and the steel also seems to be essential to a gradual coefficient of expansion gradient between the enamel and the steel.

Martin[1] states that firing enamels in an oxidizing atmosphere at 1100° to 1200°F and finishing the fire in a neutral atmosphere increases adherence, thus supporting the explanation given by the authors of this paper. This method controls the thickness of the oxide layer by control of the firing conditions, and the $Mo(OH)_3$ seems to give an automatic method of obtaining the same result.

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[1] W. G. Martin, "Oxidation Control in Firing Ground-Coat Enamels," *Ceram. Ind.*, **26** [1] 60–64 (1936); *Ceram. Abs.*, **15** [3] 85 (1935). (This volume of *Ceramic Industry* was incorrectly numbered Volume 25.)

SUPER-CERAMIC BUILDING MEMBERS*

By F. O. Anderegg

Abstract

Ceramic masonry units, properly formed of suitable raw materials and well fired, are characterized by high compressive strengths. When assembled into building members their usefulness ordinarily is limited by the weakness of mortar joints; even the inclusion of reinforcing in a mortar joint fails to develop the potentialities of the high compressive strengths and stiffness available in the units. Prestressing does, in effect, change part of the excess compressive strength into tensile strength, permitting much better application of materials, whether in beams or in columns. In the former, the underside is placed initially under compression while, even in columns, suitable prestressing reduces the buckling tendency of slender members which otherwise would cause failure far short of the compressive-strength potentialities. Analysis of the prestressing and loading operations is secured with the aid of celluloid models and polarized light.

I. Introduction

Ceramic masonry units, formed of suitable raw materials and well fired, are characterized by high compressive strengths. When assembled into building members their usefulness ordinarily is decidedly limited by the weakness of mortar joints; even reinforcing in a mortar joint fails to develop properly the potentialities of the high compressive strengths and stiffness in the ceramic units.

Prestressing does, in effect, change part of the excess compressive strength into tensile strength, permitting much better application of materials, whether in beams or in columns. In the beams, the underside is placed initially under compression, while in columns or in walls, suitable prestressing reduces the buckling tendency of slender members which otherwise would cause failure far short of the compressive-strength potentialities. An analysis of the prestressing and loading operations is secured with the use of celluloid models and polarized light.

II. Masonry Unit Strength Exceeds Wall Strength

When brick walls are permitted to carry not more than 200 pounds per square inch and are built of units having compressive strengths averaging at least 10,000 pounds per square inch, there appears to be some waste of opportunity in present-day masonry construction. An efficiency of 1 or 2% would seem to lean backward toward conservatism.

The reason for such extravagance has been the desire to construct walls with adequate load-carrying capacity, sufficient wind resistance, ability to withstand a reasonable amount of foundation movement, ample sponge capacity to absorb all except exceptionally heavy rain storms, and heat insulation to bring the radiation loss through the wall to below 0.30 B.t.u. per square foot per hour per degree F. To secure this efficiency, brick have been laboriously piled on brick by expensive mechanics and with an accumulation of weight of about 7 tons to 100 square feet of wall.

One reason for this ultra-conservative practice is the fact that a wall built up of units will carry only about 20% as much weight as a single unit; the shape factor has to be allowed for, and if a wall is constructed of ordinary masonry one brick thick, it would not be difficult to topple it over or to cause it to buckle, even when the units are fully capable of carrying the loads with an ample factor of safety.

III. Mortar Joints a Limiting Factor

Another limitation has been the mortar, which is generally the weakest point in the wall. Laid up with $^1/_2$-inch mortar joints, the bond strength will vary from 15 to about 100 pounds per square inch or more. The collapse of brickwork laid in mortar made of carbide sludge during the Long Beach earthquake warns of dangers to life and property even in the orthodox methods and emphasizes the need for conservatism.

Obviously it is necessary to produce joints of a quality similar to that of the units and to do it consistently. Some means must also be evolved to put more of the great strength in compression to work, and prestressing has seemed to offer a practical and economical answer.

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, April 1, 1936 (Structural Clay Products Division). Received April 6, 1936.

FIG. 1.—Prestressed model loaded until the initial compressive stress on the lowermost fiber has been exactly neutralized; during this operation the lower steel receives a small additional increment of loading.

In previous work with masonry,[1] it was noted that the more a unit was pounded down and the tighter the joint, the stronger the mortar and the better the bond. Furthermore, in experiments with the after-working of concrete great improvements in compaction and strength were obtained by vibrating or tamping (or troweling) the concrete from time to time even up to 24 hours of age. The mortar has considerable ability to flow during the early stages of setting and advantage may be taken of this to increase its density. These observations suggested a method of developing extremely high mortar strength and an adhesion far greater than had previously been obtained.

IV. Prestressing

A mortar of great strength is obtained by mixing 85 parts of high-quality Portland cement with 200 of well-graded sand. To give better plasticity and more perfect contact, 15 parts of air-floated shale or clay are added, which previously have been demonstrated to be free from deleterious compounds. Clay is chosen in preference to lime or fine limestone to reduce the creepage of the mortar to a minimum and to raise the compression modulus of elasticity close to that of the units.[2] The joints are pounded down to about $^1/_8$ inch, and as soon as a member is assembled it is placed under considerable compression so that the mortar continues to compact and to perfect its contact with the units.

To secure this condition of intimate and continuous contact, it is convenient to use the rods which are added for the prestressing. Ceramic units are readily fabricated with holes running lengthwise and rods can be passed through these holes, plates placed over the ends of these members, and nuts tightened to produce the desired loading. Alternate methods, where the design requirements are not so severe may involve grinding the ends of units and stringing them on rods with or without gaskets of hydraulic materials or even a neat cement paste between the units. As soon as the nuts are tightened the members may be handled.

The prestressing is done according to the particular application by stretching steel rods to a predetermined extent, whereby all or part of the member is put under compression. A column may be symmetrically prestressed to a moderate extent which reduces its buckling tendency. After prestressing, a wall, one brick thick with rods at intervals anchored to the bottom, will become resistant to wind sway, surprisingly resilient and tough and, in spite of being under compression, will carry a heavier load because of reduced bending tendency.

Obviously in a beam or rafter, the best effect is secured from prestressing. With rods running throughout the member near both the upper and lower sides, the beam may be swung into place soon after assembly, provided the rods are adequately stressed. After the beam has received its designed loading or while it is being loaded, the upper rod may be released.

The stress distribution has previously been analyzed.[3]

It would seem logical to design the units to have as small an area on the underside as is practicable so as to require less steel for prestressing. In this connection, considerable thought has been given to the use of steel of high yield points (100,000

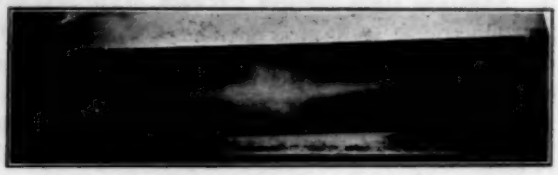

FIG. 2.—Additional loading and the lower steel is taking up the tensile load as in an ordinary reinforced beam. Failure may occur by passing the yield-point of the lower steel, by compression failure at the top of the beam, or by diagonal tension. The last type has usually appeared in these tests.

[1] (*a*) F. O. Anderegg, "Construction of Water-Tight Brick Masonry," *Jour. Amer. Ceram. Soc.*, **13** [5] 315–24 (1930); (*b*) "Watertight Terra Cotta Masonry," *ibid.*, **16** [12] 634–39 (1933); (*c*) "Watertight Brick Masonry," *Arch. Rec.*, **70**, 202 (1931); (*d*) "Masonry Cements," *Rock Prod.*, **34** [25] 40 (1931); **35** [4] 46 (1932); **35** [11] 28 (1932).

[2] While flexibility in mortar is highly desirable in the ordinary wall, where prestressing is used the mortar should be as rigid as possible, avoiding all calcareous admixtures.

[3] F. O. Anderegg and C. L. Dalzell, "Pre-Stressed Ceramic Members," *Proc. A.S.T.M.*, **35** [Part II] 447–56 (1935); *Ceram. Abs.*, **15** [4] 124 (1936).

pounds per square inch or more). Smaller rods may be used which fit in smaller holes, requiring less ceramic material to surround them and to be prestressed. The choice of steel quality will be largely economic as determined by the particular application. For highest load-carrying capacity, a well-cured mortar and a high yield-point steel are recommended with prestressing to about two-thirds of the yield-point of the steel and to about one-half of the compressive strength of the member, which means to about one-fourth of that of the units.

Erected costs are similar to those for the erection of steel of similar load-carrying capacity, the saving in weather- and fire-proofing making the prestressed ceramic building member an attractive proposition.

V. Conclusions

By proper design, it is not difficult to secure appreciable economies in construction costs, not only in reducing the weight of building members, but also in securing marked economies in the steel frame and in the labor of erection. Floor beams and joists readily fabricated of ceramic units and light steel rods can be quickly swung into place to speed up operations and to yield fireproof building members, without expensive shield-building operations. Here is a system which should receive careful consideration by the progressive clay products manufacturer, by the architect, by the building contractor, and by the man paying for building construction.

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THE EFFECT OF REPLACING DOLOMITIC LIME BY BARYTA UPON SOME PROPERTIES OF GLASS*

By Vincent E. Wessels

Abstract

The effect of replacing dolomitic lime, both in weight percentage and molecularly, by baryta upon the chemical durability, softening temperature, coefficient of linear expansion, density, index of refraction, elasticity, and several other properties was studied. Discussions of the methods, apparatus, and results are included.

I. Introduction

Glasses containing baryta have been used for optical purposes for many years, but only recently has it been introduced to any extent in other types of glassware. The properties are, in most cases, similiar to those given to glass by calcia or magnesia. Baryta decreases the solubility, though not to such an extent; it increases the density, brilliance, and index of refraction; its effect on the coefficient of linear expansion and hardness is about the same as that of lime; it decreases the specific heat; and it is believed that it decreases the elasticity and toughness when it replaces lime.

A few desirable properties which baryta imparts to glass and which were not studied to any great extent in this investigation are given. Silverman[1] found that when baryta replaces lime the resulting glasses show an increase in the speed of melting and fining and are more fusible. Zschacke,[2] studying the effect of baryta upon the viscosity of glass, found that it produces a glass of low viscosity at high temperatures and that the rate of change with a change of temperature is comparatively slow. Thus the working range of soda-silica glasses may be increased by the addition of baryta, which makes them more suitable for blown glass manufacture. An anonymous author[3] states that devitrification troubles can be reduced without impairing the chemical durability by making use of a more complex glass. In this connection, it was claimed that the ideal batch constituent for replacing a part of the lime was barium carbonate, resulting in a diminution of viscosity and easier fining. Better color and greater luster were also derived by this change. Zschacke[2] has shown, however,

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, March 31, 1936 (Glass Division). Received April 3, 1936.

[1] A. Silverman, "Use of Barium Compounds in Glass," *Jour. Soc. Chem. Ind.*, **34**, 399 (1915).

[2] F. H. Zschacke, W. Höfler, and A. Riaza, "Effect of Barium Oxide on the Properties of Technical Glasses," *Keram. Rundschau*, **40**, 534–36, 558–61 (1932); *Ceram. Abs.*, **12** [9] 324 (1933).

[3] Anon., "Use of Barium Carbonate in the Sheet Glass Industry," *Keram. Rundschau*, **39**, 576 (1931); *Jour. Soc. Glass Tech.*, **15A**, 354 (1931).

that if this substitution of baryta for lime is carried too far, devitrification will occur, especially in glasses low in soda.

Glasses containing baryta have been studied in simple series as well as glasses containing lime and magnesia, but there has been no study on the quantitative relationship of these three compounds. The present investigation was carried out to determine this relationship to some of the important properties.

Two series were outlined for this research: (1) dolomitic lime was replaced in weight percentage by baryta and (2) the lime was replaced molecularly.

The theoretical compositions of the glasses are given in Table I. Lime was introduced as freshly burned dolomitic lime, and baryta was introduced by barium carbonate rather than the sulfate (which is cheaper) because it reacts more readily with silica. A little salt cake was also added to aid in fining the glass. Batches of 1000 grams were melted in mullite-clay crucibles in a small rectangular gas-fired furnace.

TABLE I

	SiO_2 (%)	Na_2O (%)	CaO (%)	MgO (%)	BaO (%)
A-1	74.0	17.0	5.2	3.8	
A-2	"	"	4.7	3.3	1.0
A-3	"	"	4.1	2.9	2.0
A-4	"	"	3.5	2.5	3.0
A-5	"	"	2.9	2.1	4.0
A-6	"	"	2.3	1.7	5.0
A-7	"	"	1.8	1.2	6.0
A-8	"	"	1.2	0.8	7.0
A-9	"	"	0.6	0.4	8.0
A-10	"	"			9.0
B-1	74.1	17.0	5.2	3.7	
B-2	72.7	16.7	4.6	3.3	2.7
B-3	71.3	16.4	4.0	2.9	5.4
B-4	70.0	16.1	3.4	2.5	8.0
B-5	68.8	15.8	2.8	2.1	10.5
B-6	67.6	15.5	2.3	1.7	12.9
B-7	66.4	15.2	1.9	1.3	15.2
B-8	65.2	15.0	1.3	1.0	17.5
B-9	64.1	14.7	0.9	0.6	19.7
B-10	63.0	14.5	0.4	0.3	21.8
B-11	62.0	14.2			23.8

II. Chemical Durability

Inasmuch as this investigation was carried out before the standard methods were adopted, the following process was used: The glass was ground to a powder in a small disk pulverizer, separating any iron that may have accumulated from the pulverizer, and screened on a nest of standard W. S. Tyler screens on a Ro-Tap machine for five minutes; the 40- to 50-mesh powder was leached with distilled water for 24 hours at 90°C, and a fractional portion of the solution was titrated with $N/20$ hydrochloric acid using phenolphthalein as an indicator. The temperature of 90° was maintained in a constant-temperature, electrically heated, glycerine bath. As all tests were carried out in exactly the same manner, the results checked closely.

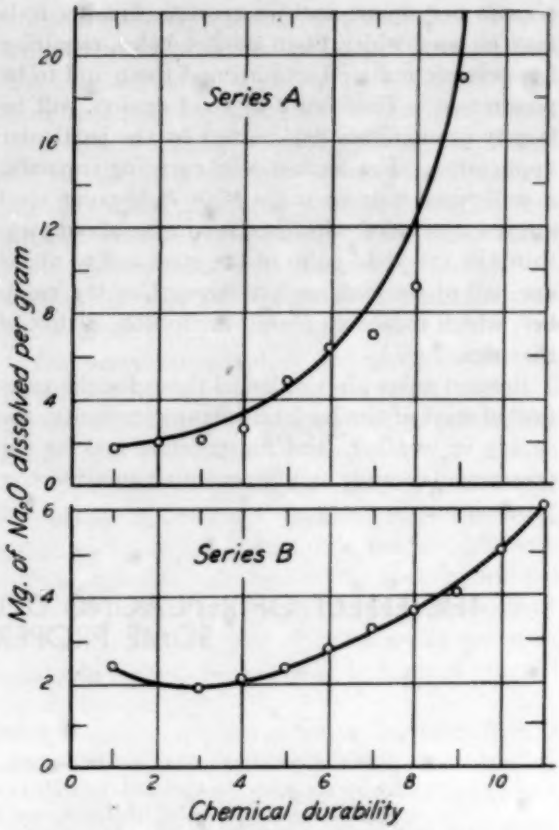

FIG. 1.—Results of the chemical durability test.

(1) Results on Chemical Durability

The results on chemical durability are shown in Fig. 1. It is noted that baryta produces glass which is more susceptible to the attack of water than the corresponding lime glasses. The decrease in chemical durability, however, is comparatively slight when only 4 or 5% of the lime is replaced by baryta, but baryta glasses containing no lime are too soluble for practical purposes, as shown by the steep slope of the curves in the latter part of both series. The curve for series B shows that the baryta glasses are not greatly inferior to lime glasses because the decrease of the soda content seems to be enough to show an increase in the chemical durability in the

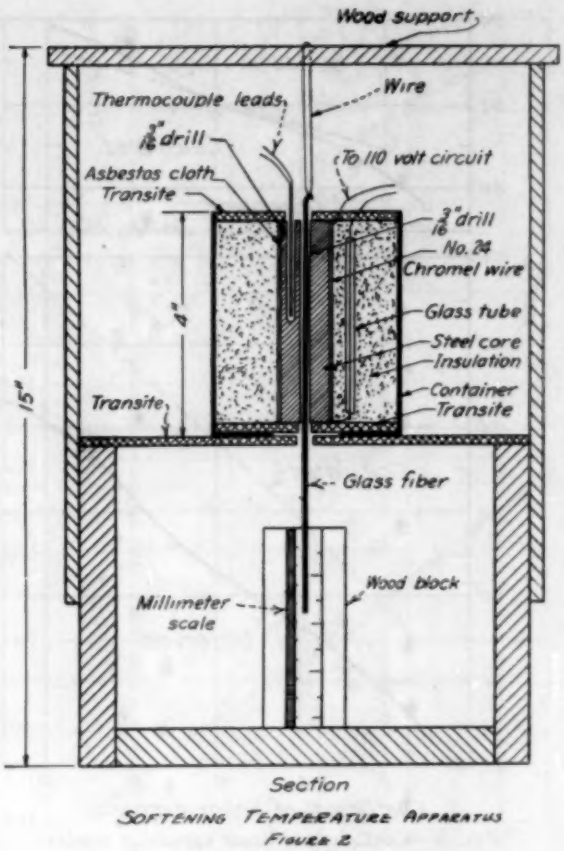

FIG. 2.—Softening temperature apparatus.

first part of the series; but, in the last part of this series, the chemical durability decreases, as in series A, because the baryta content is increasing so rapidly in comparison to the other constituents. A small amount of baryta can replace some of the lime in a high soda glass without decreasing its serviceability to any extent.

III. Softening Temperature

The test on softening temperature research was carried out according to the definition of Littleton[4]. The furnace is shown in Fig. 2. The samples were inserted when the temperature was about 50°C below the softening temperature. The furnace heated up at a rate of about 10°C per minute at the start, but this rate gradually decreased so that at the softening temperature the rate was about 5°C per minute, making possible accurate readings of the elongation of the sample.

[4] J. T. Littleton, "Method for Measuring the Softening Temperature of Glasses," *Jour. Amer. Ceram. Soc.*, **10** [4] 259–63 (1927).

(1) Results of Softening Determinations

The results (Fig. 3) show that baryta lowers the softening temperature of glass considerably when it replaces dolomitic lime. A decrease of about 40°C occurs when 9% lime is replaced by baryta in weight percentage and a decrease of about 50°C when the lime is replaced molecularly. It may be estimated that the annealing temperature of the glass is lowered about the same amount as the softening temperature when dolomitic lime is replaced by baryta.

IV. Thermal Expansion

The most important practical property dependent upon the coefficient of thermal expansion is the resistance of the glass to thermal shock. There has been some disagreement about the factors which affect thermal endurance, but it is certain that several properties must be considered. Inasmuch as the thermal expansion is affected most by a change in composition, it

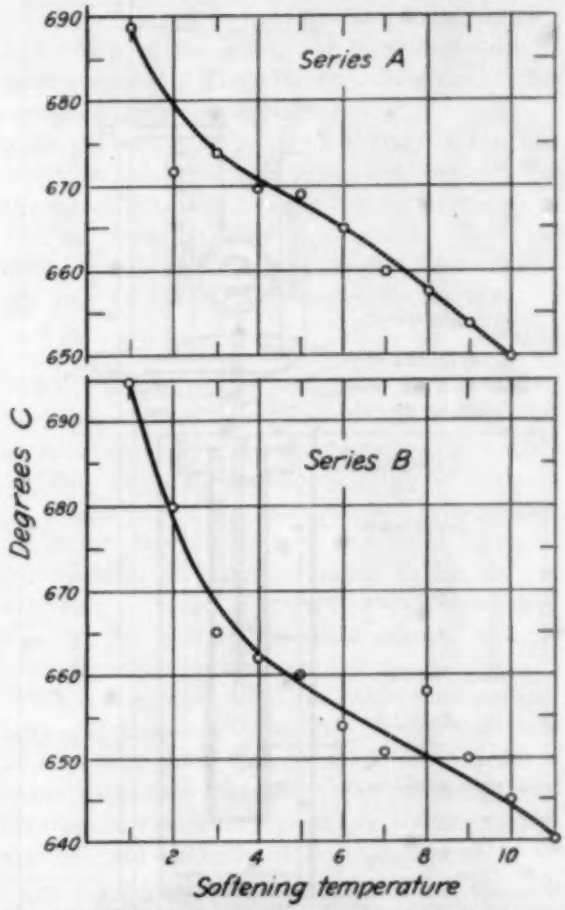

FIG. 3.—Softening temperature test results.

follows that a comparison of this property gives a fair indication as to the resistance to sudden temperature changes.[5]

The apparatus is shown in Fig. 4. The sample, a rod about one-fourth inch in diameter and four inches long, was put in the quartz tube, and the gage was securely clamped into place. The quartz tube was immersed in water at room temperature and the temperature throughout the system was allowed to equalize. The tube was then placed in the oil bath (about 120°C) and the temperatures were again equalized. The

[5] (*a*) Thermal endurance studies have been made by A. Winkelmann and Otto Schott cited in a book by J. T. Littleton and G. W. Morey, The Electrical Properties of Glass, p. 53. John Wiley & Sons, Inc., New York, 1933.
(*b*) C. G. Peters and C. H. Cragoe, "Measurement on the Thermal Dilatation of Glass at High Temperatures," *Bur. Stand. Sci. Paper*, No. 393, 39 pp. (1920); abstracted in *Jour. Amer. Ceram. Soc.*, 3 [10] 852 (1920).

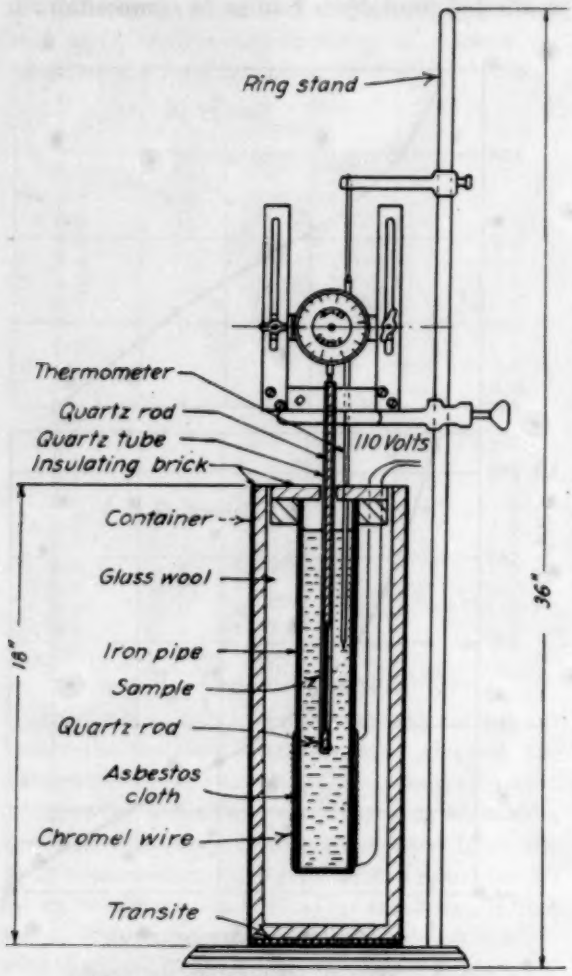

FIG. 4.—Thermal expansion apparatus.

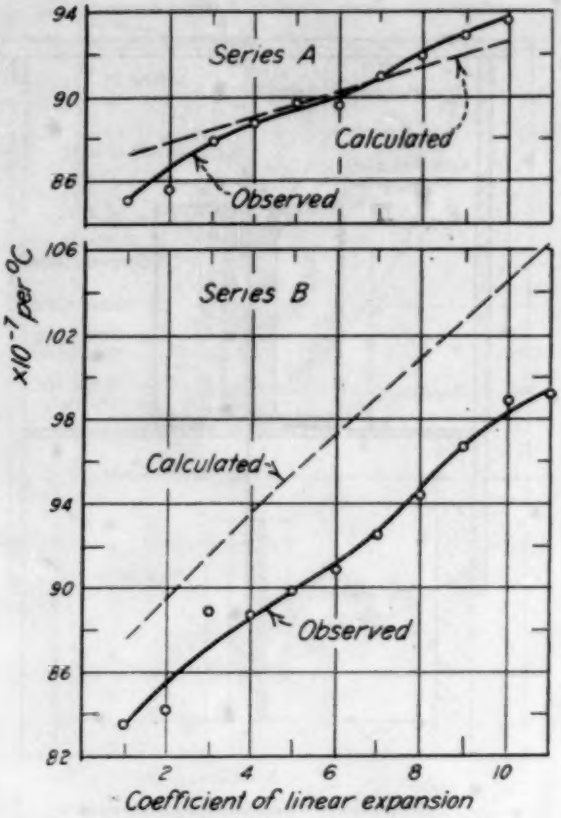

FIG. 5.—Coefficient of linear expansion results.

coefficient of linear expansion was calculated by the formula:

$$\alpha = \frac{\text{Expansion of rod}}{\text{Length of rod} \times \text{temperature difference}} + 5.0\times10^{-7}$$

The results, as found by experimentation and as calculated from the factors of English and Turner,[6] are shown in Fig. 5. Baryta increases the coefficient of linear expansion when replacing dolomitic lime but not sufficiently to decrease the serviceability of the glass. This is, nevertheless, a disadvantage because an increase in the thermal expansion decreases the resistance of the glass to thermal shock.

V. Density and Index of Refraction

The density of commercial glasses is roughly a linear function of the composition. This has been found true by many investigators and vari-

[6] SiO_2 0.05×10^{-7}
Na_2O 4.32
CaO 1.63
MgO 0.45
BaO 1.73

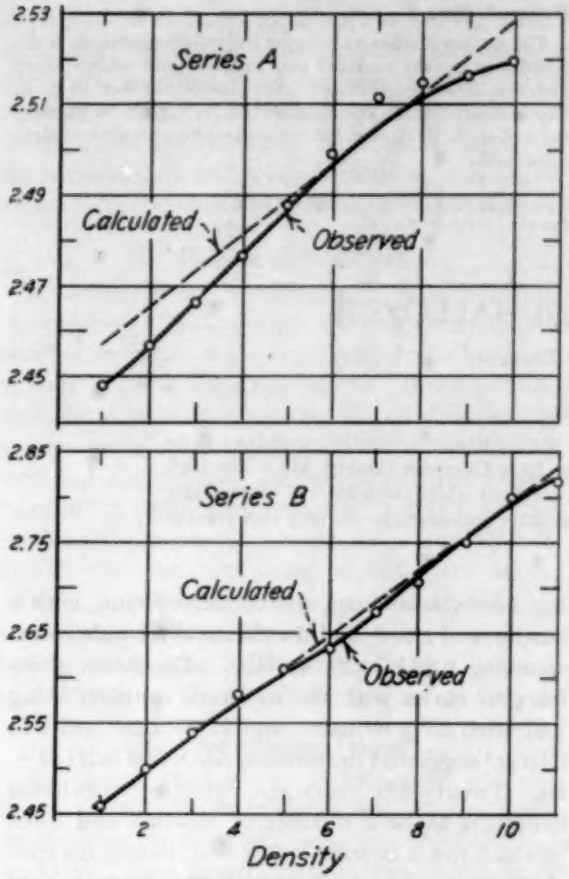

FIG. 6.—Results of density tests by the immersion method.

ous factors have been assigned to the glass-forming oxides.

The densities found by the immersion method are given in Fig. 6. Baryta increases the density quite rapidly, as was expected because of its high molecular weight. The increase follows the calculated values[7] quite closely. The curves for both series, however, flatten out near the end of the series.

The index of refraction decreased with an increase of baryta when it replaced lime in weight percentage. The index was found by comparing glass powder with oils of known index by the use of inclined illumination. As baryta and lime give glass a high refractive index, there was no difference that could be detected between the indices of the successive members of the series. Therefore only the first and last members of each series were examined. In series A, the index decreased from 1.5047 to 1.5016. When lime was replaced molecularly, the index increased from 1.5064 to 1.5346.

VI. Elasticity

An attempt was made to study the effect of baryta upon the elasticity of glass, but the results were not conclusive. Gehlhoff and Thomas[8] studied the effect of various glass-forming oxides on elasticity and, from the curves of calcia, magnesia, and baryta, it seems that baryta should decrease the modulus of elasticity as was noted in this work.

VII. Other Properties

There was no devitrification trouble at all when the glasses were melted and cooled in the crucibles. In a few cases, however, surface devitrification was noted when the rods were heated in a flame and pulled into fibers. This was noticed only with glasses A-6, A-7, and A-8.

Baryta seemed to increase the rate of melting and fining of the glass, but no definite results were recorded. The viscosity, however, is decreased at high temperatures.

Baryta not only produces a glass of low viscosity at high temperatures, but the rate of change as the glass cools is comparatively slow, and the working range is increased. This was quite evident as "gathers" of glass were drawn into rods for the various samples for the tests.

VIII. Conclusions

When baryta replaces dolomitic lime in weight percentage, the following effects are noted: (1) chemical durability decreases, slowly at first, then rapidly; (2) softening temperature is lowered; (3) coefficient of linear expansion is increased; (4) density increases almost as a linear function; (5) modulus of elasticity seems to be slightly lowered; (6) index of refraction is lowered very slightly; (7) melting time is decreased; and (8) working properties are improved.

When baryta replaces dolomitic lime molecularly, (1) chemical durability increases slightly at first and then decreases; (2) coefficient of linear expansion increases; (3) softening temperature is lowered; (4) density increases quite rapidly; (5) modulus of elasticity seems to be

[7] Computed by the use of Baillie's factors as follows:

SiO_2	2.24	MgO	3.25
Na_2O	3.20	BaO	7.30
CaO	4.30		

[8] G. Gehlhoff and M. Thomas cited in The Electrical Properties of Glass, by J. T. Littleton and G. W. Morey; pp. 47–50. John Wiley & Sons, Inc., New York, 1933.

lowered; (6) index of refraction increases; (7) melting time is decreased; and (8) working properties are improved.

From a comparison of some of the above properties, it may be concluded that the thermal endurance of the glass is decreased slightly, but not enough to affect its serviceability, by the replacement of dolomitic lime by baryta.

Acknowledgment

The author wishes to express his indebtedness to S. R. Scholes, who first outlined this problem and under whose direction it was carried out. He is also indebted to E. P. MacNamara for the construction of the expansion apparatus and to E. E. Beeton for the constant-temperature glycerine bath.

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NOTES ON MISSOURI HALLOYSITE*

By Frank J. Zvanut

Abstract

A brief discussion of the properties of halloysite is presented, together with the results of tests made on the firing behavior of halloysite from Lawrence County, Mo. The high refractoriness, apparent colloidal nature, and excellent white color are the outstanding favorable qualities, while the extreme firing shrinkage appears to be the only unfavorable feature.

I. Introduction

A six-foot seam of white, friable clay containing porcelain-like inclusions occurs at a depth of 42 feet in an abandoned shaft near Aurora, Lawrence County, Missouri. The first reference to this deposit was made by Wheeler,[1] who stated that this white material, known to be halloysite, had been used to some extent by local potteries during the last part of the 19th Century. Interest in the clay was revived by the Missouri Geological Survey during its study of Missouri bleaching clays. The results of their investigation, together with a thorough description of the geology and the location of the deposit, are published in Appendix VI of the Biennial Report for 1933–34.[2]

II. Properties of Halloysite

Ross and Kerr[3] distinguish between two types of halloysite: one is white or light-colored, porous, friable, and almost cottony in texture; the other is dense, nonporous, and porcelaneous. The colors vary from white, gray, buff, and faun, in the pure varieties, to red and brown in the ferruginous types. Winchell[4] describes halloysite as being insoluble and apparently amorphous, with a hardness of 1 to 2, and the chemical formula corresponding to $Al_2O_3 \cdot 2SiO_2 \cdot nH_2O$. The index of refraction varies with the moisture content, being 1.47 with 25% moisture and 1.595 after ignition. Clarke[5] suggested the formula $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$ + aq. Twenty-five years ago, Stremme[6] concluded halloysite to be a mixture of alumina and silica gels and not a definite compound, basing his conclusions on the similarity of the properties of mixed gels to those of the natural minerals which he studied. Thugutt,[7] as a result of experiments using cobalt nitrate, methyl blue, rhodamine, and methyl orange as stains, showed no free alumina to be present and concluded that halloysite is a definite chemical compound. Investigations since that time have established the mineral to be a definite compound, submicroscopically crystalline, and isotropic. Ross and Kerr[3] have published results of optical, chemical, and X-ray studies of this material and have pointed out that the $SiO_2 : Al_2O_3$ ratios vary from 2.06:1 to 1.65:1 for samples from various localities.

The lattice structure of halloysite and the changes that take place in the space lattice on

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, April 1, 1936 (White Wares Division).

[1] A. A. Wheeler, "Clay Deposits," *Mo. Geol. Surv.*, 11 [1st series] 186–87 (1896).

[2] H. F. Smith, D. S. Grenfell, and H. S. McQueen, "The Occurrence of Halloysite in Lawrence County, Missouri," *Mo. Geol. Surv. Biennial Report*, 1935.

[3] C. S. Ross and P. F. Kerr, "Halloysite and Allophane," *U. S. Geol. Surv. Prof. Paper*, No. 185–G, pp. 135–48 (1934).

[4] A. N. Winchell, Elements of Optical Mineralogy. John Wiley and Sons, Inc., New York, 1933.

[5] F. W. Clarke, "The Data of Geochemistry," *U. S. Geol. Surv. Bull.*, No. 616, pp. 610–11 (1916).

[6] H. Stremme, "Properties of Mixed Gels of Aluminum and Silicic Acid and Their Relation to Allophane, Halloysite, and Montmorillonite," *Centr. Mineral Geol.* [Berlin], pp. 622–32 and 661–69 (1908); abstracted in *Chem. Abs.*, 3, 298 (1909).

[7] St. J. Thugutt, "Are Allophane, Halloysite, and Montmorillonite only Mixtures of Alumina and Silica Gels?" *Centr. Min.* [Warsaw], pp. 97–103 (1911); abstracted in *Chem. Abs.*, 5, 1575 (1911).

drying to 50°C have been worked out by Mehmel,[8] who called the dried product "metahalloysite" and assigned it to the space group C_s^2 as compared to C_s^4 for kaolinite. Ksanda and Barth,[9] however, advocate the recalculation of the structure of halloysite because it was based on an incorrect idea of the structure of dickite.

III. Purpose of Investigation

Although X-ray spectrographs have revealed the presence of halloysite in varying amounts in a number of clays, little is known of the behavior of this mineral on firing above 1000°C. Ross and Kerr[3] presented the results of dehydration studies on halloysite, and Houldsworth and Cobb[10] recorded endothermic phenomena in the ranges from 50° to 130°C and from 490° to 560°C and an exothermic phenomenon in the range from 880° to 930°C. No data on firing of halloysite above 1000°C, however, have been published and, for this reason, results obtained during the routine testing of Missouri halloysite under the auspices of the Missouri Geological Survey are presented.

IV. The Missouri Deposit

The sample used in this investigation was obtained by the Missouri Geological Survey from the shaft on the Sumners farm, Sec. 20, T. 26 N., R. 25 W., Lawrence County. The clay occurs either in masses of blanket-like deposits between beds of chert or flint or in irregular masses in zones of fracturing or brecciation. A considerable portion is snow-white, slightly friable, and commonly granular in texture. A hard, vitreous variety having a waxy luster locally grades into white, fossiliferous, unaltered chert.

The amount of halloysite in this district is not known because of insufficient prospecting; about 30 tons, however, have been removed from the Sumners deposit and at least an equal amount is available at present.

V. General Characteristics of Missouri Halloysite

X-ray spectrographs of the material from the Sumners deposit were made by Kerr,[11] who concluded that the halloysite contained some alunite. It is therefore similar to other varieties described in the report of the United States Geological Survey.[12]

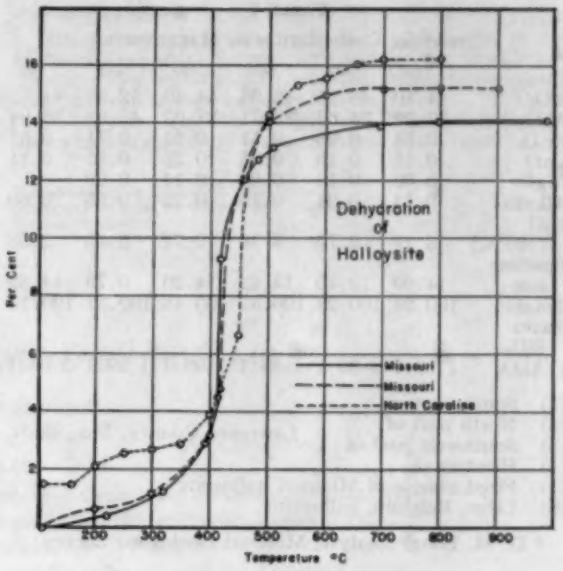

FIG. 1.

Very white material, obtained by removal of a thin surface of ferruginous clay, contained 15% moisture. This material was easily ground to pass through a 20-mesh screen, and, upon addition of water and pugging, a pasty plasticity was developed, similar to moistened corn meal. The material had a long water-of-plasticity range (33 to 50%). It dried easily, without cracking, with a 7.5% drying shrinkage. The modulus of rupture of ten bars when dry averaged 289 pounds per square inch. The true specific gravity was found to be 2.3534.

The clay effectively bleached the yellow kerosene used in the dry volume determinations for the firing-behavior test. This bleaching action is probably due to the colloidal nature of the material, which accounts in part for the use of halloysite in the manufacture of colloidal slurries for bonding purposes.[13]

The chemical analyses of samples from several parts of the Sumners mine and one typical halloysite from Belgium, together with the analysis of a fired specimen, are presented in Table I.

[8] M. Mehmel, "The Structure of Halloysite and Metahalloysite," *Z. Krist.*, **90** [1] 35–43 (1935); *Ceram. Abs.*, **14** [11] 291 (1935).

[9] C. J. Ksanda and Tom F. W. Barth, "Structure of Dickite and Other Clay Minerals," *Amer. Mineralogist*, **20** [9] 631–37 (1935); *Ceram. Abs.*, **15** [1] 40 (1936).

[10] H. S. Houldsworth and J. W. Cobb, "The Behavior of Fireclay, Bauxite, etc., on Heating," *Trans. Ceram. Soc.* [Eng.], **22**, 111–37 (1922–23); *Ceram. Abs.*, **3** [2] 48; [10] 296 (1924).

[11] P. F. Kerr, private communication.

[12] See footnote reference 3.

[13] Kraus Research Laboratory, "Colloidal Slurry, a New Bonding Material," *Ceram. Ind.*, **23** [6] 392 (1934); *Ceram. Abs.*, **13** [9] 246 (1934).

TABLE I

CHEMICAL COMPOSITION OF HALLOYSITE*

	(1)	(2)	(3)	(4)	(5)	(6)
SiO_2	44.10	48.28	42.94	44.40	52.96	44.75
Al_2O_3	37.99	34.62	38.71	37.93	45.21	36.94
Fe_2O_3	0.51	0.98	0.51	0.51	0.71	0.31
CaO	0.15	0.15	0.05	0.25	0.25	0.11
MgO	0.09	0.16	0.20	0.11	0.02	
Alkalis	0.14	0.24	0.15	0.22	0.03	0.60
H_2O (105°C)	3.17	2.75	3.39	2.77	0.35	2.53
Ignition loss	14.09	13.10	14.42	14.29	0.79	14.89
Totals	100.24	100.28	100.37	100.48	100.32	100.13
Ratio SiO_2:- Al_2O_3	1.99:1	2.33:1	1.88:1	1.98:1	1.99:1	2.06:1

(1) South part of
(2) North part of
(3) Southwest part of } Lawrence County, Mo., shaft.
(4) Heading of
(5) Fired sample of Missouri halloysite.
(6) Liége, Belgium, halloysite.

* D. M. Long, Analyst, Missouri Geological Survey.

VI. Dehydration Test

The dehydration data (Table II) were obtained from a molded one-inch cube which was suspended in a small electric furnace from a triple-beam balance by a platinum wire, the temperatures being held constant until no further loss in weight was indicated. The curve obtained for the Missouri halloysite (Fig. 1) corresponds closely to published curves. The major portion of the chemically combined water was driven off between 400°C and 500°C.

TABLE II

DEHYDRATION TEMPERATURES OF HALLOYSITE

Missouri		Missouri*		North Carolina†	
Temperature (°C)	Loss of water (%)	Temperature (°C)	Loss of water (%)	Temperature (°C)	Loss of water (%)
110	0.00	110	0.00	Room	0.00
220	0.42	200	0.65	110	1.44
320	1.25	300	1.20	160	1.47
392	2.99	400	3.20	200	2.10
415	4.51	415	4.80	250	2.54
457	12.01	500	14.1	300	2.68
480	12.74	600	15.0	350	2.98
509	13.27	700	15.2	400	3.86
693	13.90	800	15.2	450	6.72
797	14.06	900	15.2	500	14.32
986	14.06			550	15.32
				600	15.52
				700	16.18
				800	16.22

* A. F. Smith, D. S. Grenfell, and H. S. McQueen, see footnote reference 2.
† C. S. Ross and P. F. Kerr, see footnote reference 3.

VII. Fusion Value

The pyrometric cone equivalent of Missouri halloysite was found to be 35+. This value was checked by the laboratories of the University of Washington.[14]

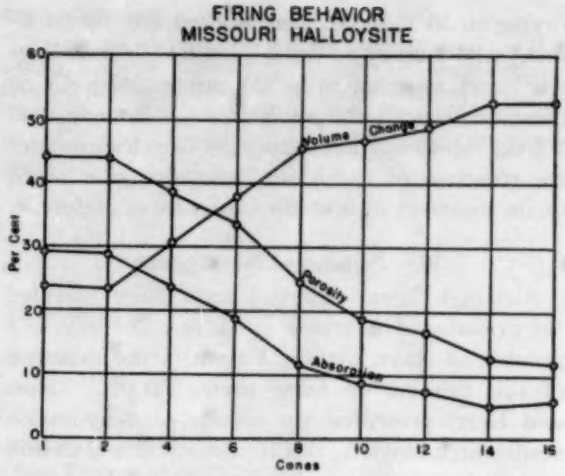

FIG 2.

VIII. Firing Behavior

The firing-behavior test was made in accordance with the standard procedure,[15] and the results obtained are embodied in Table III and Fig. 2.

The gray color in the specimen fired at the lower temperatures (Table III) probably was due to coloring matter absorbed from the kerosene which apparently was burned out completely at cone 6. Most of the shrinkage occurred between cones 2 and 8. As the firing temperature was increased, the specimen seemed to increase in strength and become denser in structure.

TABLE III

FIRING BEHAVIOR OF MISSOURI HALLOYSITE

Cone	Temp. (°C)	Volume change (%)	App. porosity (%)	Absorption (%)	Color
01	1110	23.67	44.05	29.09	Gray
2	1135	23.22	44.10	28.99	Gray
4	1165	30.70	38.55	23.57	Light gray
6	1190	35.56	33.55	18.68	White
8	1225	45.05	24.40	11.75	"
10	1260	46.60	18.70	8.72	"
12	1310	48.80	16.95	7.56	"
14	1390	50.50	12.35	5.29	"
16	1450	50.40	12.30	5.73	"

Brick were made from calcined halloysite bonded with raw halloysite in ratios up to 75:25. These showed promise and would possibly justify further study.

[14] Hewitt Wilson, private communication.
[15] *Jour. Amer. Ceram. Soc.* [Year Book], 1921–1922.

IX. Summary

A brief discussion of the properties of halloysite is presented, together with the results of tests made on the firing behavior of halloysite from Lawrence County, Missouri. The high refractoriness, apparent colloidal nature, and excellent white color are the outstanding favorable qualities, while the large firing shrinkage appears to be the only unfavorable characteristic.

Acknowledgments

The author wishes to thank H. S. McQueen of the Missouri Geological Survey, who secured the sample and promoted the investigation; and the others whose assistance has been acknowledged in the text; also C. M. Dodd, O. R. Grawe, and W. T. Schrenk, Missouri School of Mines and Metallurgy, for suggestions and advice.

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DE-AIRING IN AN ORDINARY PUG MILL*

By Kenneth Stettinius

Abstract

In the top of the pug mill, in the region where the relatively air-free press cakes are being churned and compacted, carbonic acid gas is substituted by displacement for the small amount of air which usually becomes entrapped. Visible gas blebs in the pug are eliminated or minimized, drying losses are greatly reduced, and the integrity of the product is improved. Methods of testing, visual and quantitative, are described to develop and indicate the presence of gases in the pugged clay. The results are illustrated.

I. Introduction

Air, in a plastic clay mass, either dissolved or gaseous, is generally recognized to be a stumbling block to the attainment of the highest quality in a finished product. Shapes formed from a body containing gaseous air are handicapped from the start because the blebs are the nuclei for cracks which, in turn, are the principal cause of drying losses in thick sections; furthermore, many large disk-like pores remain after the firing process, constituting local areas of poor quality. Dissolved gases in the pugged clay become harmful when the drying temperature raises the water-vapor pressure to a point where the gases are driven out of solution. A reduction of pressure inside of the drying clay mass may also cause the liberation of gaseous air from solution.

By making a thorough study of a pug mill, it can be adjusted and developed to a degree where it will deliver a pug of clay which is almost free from visible blebs. To use such clay successfully, one must pay strict attention to the feeding of the pug mill and to the formed ware along through the drying. The vacuum-slip process of preparing clay[1] has accomplished the complete removal of air from the slip, and drying problems have been simplified because of the absence of blebs. The only air present in the pugged clay is the small amount dissolved and thoroughly scattered through the mass.

In the top of the pug mill in the region where the press cakes are being churned and compacted, a small amount of air is usually entrapped. As this air and clay progress down and out through the mill, the churning and smearing action in conjunction with the pressure encountered causes the air to dissolve in the water of the mixture. In the usual case, where the vacuum-slip process is not used, the filter-press cakes are already saturated with dissolved air and the air entrapped in pugging is reluctant to go into, or stay in, solution; the result is lamination of the pug. It was thought that if the air in the top of the pug mill were replaced with a gas, which is much more water-soluble than air, the water would hold the gas in solution more tenaciously and at higher drying temperatures.

Note: The solubility of carbon dioxide is 179 parts in 100 parts of water at 0°C, while the figure for air is only about 2.5.* Carbon dioxide has 75 times the solubility of air at 0°C, 54 times the solubility of air at 20° and at 100°C, ten times the solubility compared with air at 0°C.

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* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, April 1, 1936 (White Wares Division).

[1] G. W. Lapp, "Vacuum-Slip Process of Removing Air from Clay Bodies," *Jour. Amer. Ceram. Soc.*, **11** [2] 61–67 (1928).

* Smithsonian Physical Tables, p. 172. 7th ed., Smithsonian Institution, 1921.

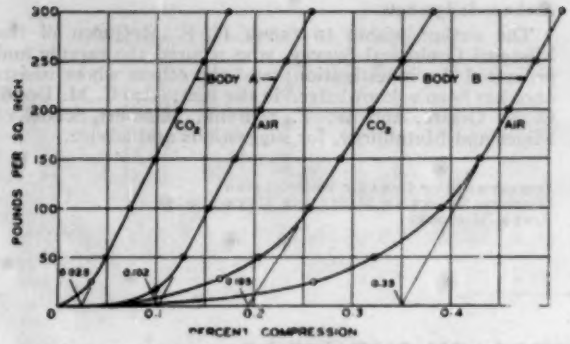

FIG. 1.—Outside commercial bodies as pugged.

Several possible gases were considered but, because of its cheapness, safeness, and high specific gravity (1.5), carbon-dioxide gas was selected for this experimental work.

II. Experimental

To apply the gas to the mill at a point below the air-gas line (to avoid mixing air with the gas and interference with the feeding of the mill), the gas was led down through a hole drilled in the vertical shaft of the mill to a point below the bearing and then out horizontally and through a small pipe down the side of the shaft to a point just below and back of the top knife. The gas was allowed to flow into the mill at a rate of about 2 pounds per hour for two hours while the clay was being pugged. Several pugs of this treated clay, 3 inches in diameter and 4 inches long were then taken to the laboratory and heated in oil for two hours to drive the dissolved gas out of solution. A fresh pug of clay was used for each heating test which covered the temperature range from 100° to 180°F in increments of 10°. The pugs were then cooled to room temperature in one-half hour or less and tested for their gaseous content in a compression bomb fitted with a dial gage capable of

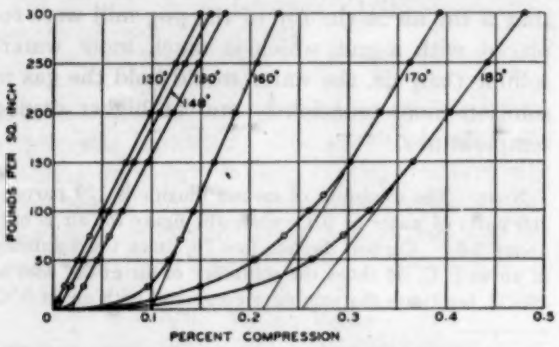

FIG. 2.—Clay pugged in air; compressibility at room temperature following heat treatment.

indicating a movement of $^1/_{20,000}$ inch. This compression bomb has been described by Lapp.[2]

The clay to be tested is carefully immersed in oil in the cylinder, the oil is adjusted to the desired working level, the plunger is inserted, and the air above the oil escapes completely through a

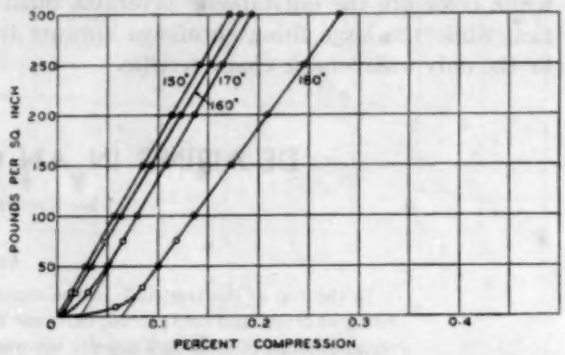

FIG. 3.—Clay pugged in carbon dioxide; compressibility at room temperature following heat treatment.

valve in the plunger. Pressure applied to the plunger will cause the gage to indicate depressions which will plot in a straight line from the origin if no easily compressible blebs are present in the clay. With this precision instrument, it is easy to measure gases accurately in the clay as low as 0.01% by volume.

III. Results

Parallel heating and compression tests were made on the regular clay pugged in air. Compression tests were made also on two outside com-

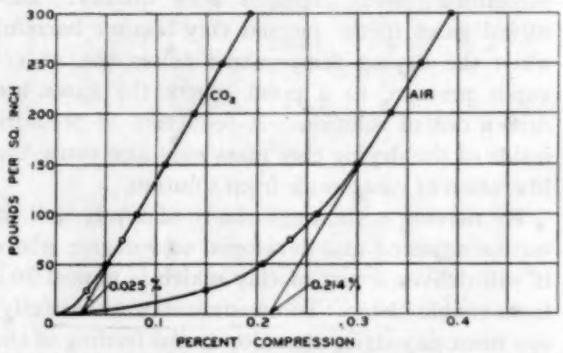

FIG. 4.—Compression of clay at room temperature after heating 2 hours at 170°F.

mercial bodies. Blebs were visible in these bodies as pugged and no heating test was required to

[2] G. W. Lapp, "Qualitative Determination of Air Content in Plastic Clay or Porous Bodies," *Jour Amer. Ceram. Soc.*, **17** [7] 204–208 (1934).

show the beneficial effects of the carbon dioxide (Fig. 1).

An examination of the compression curves in Fig. 2, which are the results of the tests on a regular body, reveals that only about 0.005% by volume of air had been driven out of solution by the two-hour heat treatment of 140°F. All compressions up to and including 130°F were straight lines from the origin which proves that they were free from blebs. Compressions of pugs heated at 150°, 160°, 170°, and 180°F show successively increasing amounts of air. Figure 3 shows the effect of the higher solubility of carbon dioxide since only about 0.005% was expelled from solution after two hours at 160°F. All compressions, up to and including those on clay heated at 150°, are straight-line graphs from the origin and therefore free from gas. Compressions of pugs previously heated at 160°, 170°, and 180°F show successively increasing amounts of carbon dioxide, but the total amount for any temperature is much less than in the case of the air-pugged clay as shown in Figs. 4 and 5. The parts of the graphs in this figure for clay heated above 180°F and represented by dotted lines are only estimated. Up to 180°, the pug remained intact, but at 190° the pressure of the air or gas and water-vapor, coupled with the fact that the clay is less plastic at

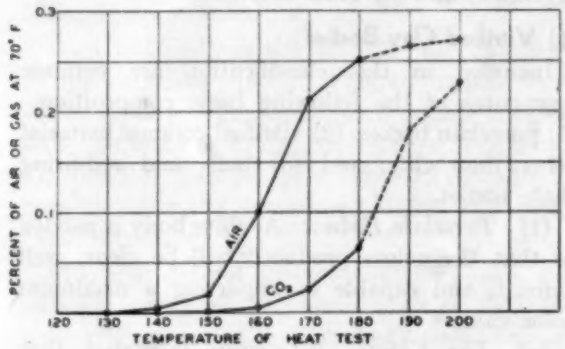

FIG. 5.—Gases driven out of solution by the heat test.

FIG. 6.

elevated temperatures, caused them to split partly open, allowing the gases to escape.

A slice of clay about one-quarter inch thick, cut longitudinally from the center of air-pugged clay after the heat test at 140°, after stretching will show the presence of only two or three blebs, which total up to about 0.005% in the compression test. A similar procedure on similar clay after the 150° heating will disclose perhaps 25 to 30 small blebs as shown on Fig. 6. This photograph depicts on the left clay pugged with carbon dioxide; on the right, clay pugged in air after both have been heated to 150° for three hours.

Most of the experimental work was done on clay pugged from air-free filter cakes. This pugged clay was also free from gaseous air. The quality of this clay could not be determined by ordinary methods, and heating was employed to expand dissolved gases out of solution and to determine their amount by means of a compression volumeter. The most definite improvement occurs in the body pugged from air-free cakes because all of the gas present in that case is the gas entrapped by the pug mill.

A definite improvement was also observed from a more limited number of tests performed on other commercial bodies pugged in air and in carbon dioxide by ordinary pug mills.

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LE ROY, NEW YORK

COLORED CERAMIC AGGREGATE FOR DECORATIVE CONCRETE*

By C. W. Planje

Abstract

The formulation and preparation of colored ceramic aggregate for concrete was investigated. Studies indicate that these aggregates can be used in concrete facings to produce colorful and decorative effects. Physical tests of ceramic aggregates in concrete are also discussed.

I. Introduction

The use of ceramic materials with concrete is not new. A great deal of work has already been done on colored ceramic particles which are especially adaptable to the roofing trade.[1]

The investigation on which this paper is based has been conducted by the Development Department of the Portland Cement Association. It was the purpose to study all methods of producing colored ceramic granules or aggregate for use in concrete, and stress was laid upon the specifications and properties desired as well as upon the economic factors.

II. Specifications for Aggregate

The American Society for Testing Materials Standards designate that concrete aggregate must be clean, hard, strong, and durable. A compilation of existing data on the results of freezing and thawing tests, flexural and compressive strength tests, and actual performance tests on concrete containing regular aggregate has furnished a basis for colored ceramic aggregate specifications.

These specifications are as follows:

(1) The aggregate particles must be clean, hard, strong, and durable.

(2) The aggregate particles should indicate no planes of weakness or laminations and should not be flake-like in character.

(3) The aggregate should have a low absorption; below 1% is desirable, but up to 4% is permissible. The absorption factor is reported in terms of dry weight after 24 hours immersion in water at 70°F.

(4) The color of the particle should be clear and well defined and should penetrate beneath the surface at least one-half the distance from the surface to the center of the particle. This precautionary specification is added so that any undue wear, caused by mixing or finishing processes or due to exposure, will have no effect upon the color imparted by the aggregate.

(5) The aggregate particles when crushed should be cubical in shape, or nearly so, to provide an adequate surface for cement adherence.

(6) The aggregate particles should possess a semigloss surface after fracture to insure a pleasing appearance and a surface which can be readily cleaned.

III. Scope of Investigation

The following three types of aggregate were investigated: (1) vitrified clay particles or aggregate, (2) coated and impregnated clay aggregate, and (3) glass aggregate.

(1) Vitrified Clay Bodies

Included in this classification are ceramic aggregates of the following basic compositions: (1) porcelain bodies, (2) vitrified ceramic material other than clay, and (3) buff- and red-firing shale bodies.

(1) *Porcelain Bodies:* A white body is needed so that the colors produced will be clear, well defined, and capable of imparting a maximum color value.

(*a*) *The Clays:* A survey indicated that clays of primary and secondary origin were satisfactory and that washing was not essential except to keep the amount of impurities reasonably constant. The iron content was of paramount importance, results indicating that clays with a Fe_2O_3 content above 1% were not satisfactory.

Impurities such as biotite, which breaks down into hydrated micaceous minerals and ultimately leaves specks in the fired body, are not so important due to the crushing into relatively small

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, April 1, 1936 (White Wares Division). Received March 27, 1936.

[1] United States patents have been issued on this subject to (*a*) W. H. Alton, 1,677,701 (1928); *Ceram. Abs.*, **9** [11] 997 (1930); (*b*) H. C. Fisher, 1,766,815 and 1,742,440 (1930); *ibid.*, [9] 802–803; (*c*) G. H. Brown, 1,831,784 (1931); *ibid.*, **11** [1] 68 (1932); (*d*) J. C. Pelton, 1,233,501 (1917); (*e*) R. L. Atkinson, 1,925,065 (1933); *ibid.*, **12** [10–11] 408 (1933); and (*f*) Leslie Brown, 2,007,742 (1935); *ibid.*, **14** [9] 236 (1935).

particles. The ultimate fired product, either as large irregular masses before crushing or small particles after crushing, has no definite shrinkage limits or finished product quality demands. It is possible, therefore, to compensate for quartz and feldspathic impurities in the clay by the adjustment of the fluxing components.

The clays found to be suitable included those from New Jersey, Tennessee, Florida, Georgia, Pennsylvania, and Alabama.

(*b*) *Fluxes:* For the fluxing constituent necessary to lower the vitrification temperature of the kaolins tested, the following materials were tried: glass cullet containing lead, glass cullet (leadless), soda feldspar, potash feldspar, fluorspar, dolomite, blast-furnace slag, and pegmatite.

The glass cullet, both lead and leadless, was satisfactory as a flux, but the high prices quoted on finely ground material made their use impractical.

When used with a kaolin, 30% of either glass was found to be sufficient to produce a vitreous body at cone six having an absorption of 0.47% after a 24-hour water-immersion period. The resultant body also had a glasslike fracture with a semigloss surface finish. The addition of color oxides and pigments produced clear, well-defined colors. The nature of the added glass flux naturally depended upon the color desired and the coloring components used.

Soda feldspar was not deemed practical owing to the excessive amount required to produce a vitreous body. The result with potash feldspar, although more favorable, was judged impractical for identical reasons. The tests on potash feldspar included the Tennessee, Maine, and South Dakota feldspars.

Fluorspar did not prove satisfactory as a flux addition owing to the impossibility of obtaining a dense structure of the clay body under average control.

Dolomite, when added to the kaolin, had no apparent effect upon the absorption of the resultant body.

Blast-furnace slag was effective as a flux when added in quantities totaling approximately 50%, but the resultant color was far removed from the white-colored basic body desired.

The addition of pegmatites was very successful in most cases, paralleling results obtained with potash feldspar. The use of pegmatites is naturally dependent upon their chemical composition, which may affect such physical properties as fusion temperature and color.

After testing the various fluxing agents, it became apparent that the addition of but one of these would not produce a balanced body composition resulting in a satisfactory aggregate particle. It was decided that the clay-lime-feldspar eutectic should provide a possible solution, and as a result numerous tests were made using various proportions of South Dakota feldspar, Ohio dolomite, and a New Jersey clay. The following formula (percentage by weight) represents the most suitable vitreous body obtained at cone 6, having an absorption of 0.3% after 24 hours' immersion in water at 70°F: kaolin 40%, dolomite 15%, and feldspar 45%.

It must not be concluded that this is the only possible composition. Any clay body that will fire white to vitrification at a temperature commercially feasible and at a cost low enough to warrant the use of the material should be satisfactory for aggregate purposes.

Color was imparted to this experimental body by the addition of the oxides of metals or prepared inorganic pigments such as are used in the pottery trade. Another method of color addition carried out in this investigation was the incorporation of color in the fluxing medium.

In the method of preparation of the aggregate particles, the body components and color media may be ground intimately with water in a ball mill, or the body components may be blunged, while the coloring components are ground in a ball mill with a portion of the body slurry and subsequently added. After a thorough grinding or mixing period, the entire mass is dewatered to a plastic consistency and dried.

(1) The filter cake, after drying, is fired to vitrification. Filter cakes of like colors may be stacked one upon the other.[3] Inasmuch as the material is to be crushed, the sticking of filter cakes presents no problem. The fired filter cake is crushed to the desired maximum size, screened, and graded into the following mesh classifications:

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[3] The laboratory equipment for firing consists of a Denver Fire Clay kiln, No. 100. For the purpose of this investigation, it was decided to limit the maximum temperatures attainable to cone 7 or 2210°F.

Mesh No.	Screen size for passing	Retained on (screen-mesh)
1	¾ in.	4
2	4-mesh	6
3	6- "	8
4	8- "	14
5	14- "	20
6	20- "	

To produce the proper shaped particles, this vitrified material should be crushed by an impact crusher of the hammer- or rolling-ring type.

(2) An alternate method is to crush the dried filter cake to the maximum desired size before firing. By using specially designed roll crushers or cutters, particles can be produced which are entirely satisfactory for use in concrete.

To illustrate this type of porcelain aggregate developed during this investigation, some representative formulas are given in Table I.

TiO_2) should be low enough to prevent contamination of the ultimate desired color; and the fired body incorporating this material should produce strong, durable aggregate particles with a pleasing surface texture.

In preparing aggregate particles, the procedure is identical with that followed with the porcelain-type aggregate. With amorphous siliceous materials, where no plasticity is evident, it is necessary to add some colloidal suspension agents, such as bentonites or the alginates of ammonium or sodium. This procedure is necessary only where settling of the body components causes difficulty in the manufacturing operation.

The pegmatites were practical substitutes for feldspar and produced white vitreous porcelain bodies at cone 6 when used in the following body

TABLE I

FORMULAS OF PORCELAIN-TYPE AGGREGATE IN PERCENTAGE BY WEIGHT

No. Color	493 Light blue	430 Medium blue	460 Dark blue	426 Yellow	542 Light green	538 Dark green	581 Blue-green	571 Pink
Potash feldspar	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Dolomite	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Kaolin	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Cobalt oxide	0.2		1.0					
Color 27		3.0						
Color 418*				5.0				
Color 68†					2.0			
Color 822D†						5.0		
Color 5085‡							2.0	
Color 5077‡								2.0

* Supplied by the Vitro Manufacturing Co.
† Supplied by the R. & H. Chemical Dept., E. I. du Pont de Nemours & Co.
‡ Supplied by the B. F. Drakenfeld & Co.

Color 27 has the following formula:

Flint	47.0
Cobalt oxide	28.0
Ball clay	9.0
Potassium nitrate	6.0
Zinc oxide	10.0
	100.0

Color No. 27 was dry mixed, calcined in a lined sagger at 1170°C, ground wet in a ball mill, dried, and screened through a 150-mesh sieve.

(2) *Vitrified Ceramic Materials Other Than Clay:* The materials included under this classification are pegmatites (North Carolina), volcanic rock deposits (southern California), amorphous siliceous materials (Tennessee), nepheline syenite, and pyrophyllite.

These materials should be capable of vitrification through heating; the total content of color-producing impurities (such as Fe_2O_3 and

composition: pegmatite 55%, dolomite 5%, and kaolin 40%. The pegmatites alone, fused at cones 7 to 8, could be used as an aggregate base except for their glassy structure and lack of plasticity.

The volcanic rock, when fluxed with 10% of sodium carbonate, gave a good base at cone 6 for ceramic aggregate and produced clean, clear colors with the addition of metallic oxides and prepared pigments. Good natural plasticity was an advantage in handling this material.

The amorphous siliceous materials were found

to be practical only as direct substitutes for the kaolin in the porcelain bodies. Owing to their expected lack of plasticity, the addition of 0.5% of ammonium alginate was necessary to prevent settling. The following range of five compositions gave satisfactory results: amorphous silica 40%, dolomite 25 to 5%, potash feldspar 35 to 55%, and NH_4 alginate 0.5%.

(3) *Buff- and Red-Firing Shale Bodies:* Samples of the following clays were used in these tests: Lawrence County Clay (Ohio), domestic ball clay (Maryland and Kentucky), siliceous ball clay (Maryland and Pennsylvania), No. 2 fire clays (Illinois), and "sagger clays" (Tennessee).

All clays in this group fired to a clear buff color at cone 4 and varied only in the degree of plasticity and vitrification. Since it was desired that a minimum or no fluxing component be added, the clay vitrifying at the lowest temperature and still retaining all other desirable properties was judged to be the most suitable. Lawrence County clay, fluxed with 5% of leadless glass cullet, gave a dense vitrified ceramic particle of a light, clean buff color with an absorption of 0.15%.

The study of red-firing clays included only the iron-bearing shales of Illinois, found in such localities as Streator, Danville, and Dayton. When used alone they should be fired to temperatures not exceeding cones 2 to 3.

The black-firing clays studied were a German clay[3] and domestic clay.[4]

The German clay fired to a dense, vitrified gray-black aggregate particle at cones 04 to 05 with an absorption of 0.45%. The domestic clay produced a similar particle at cone 3 with an absorption of 0.75%.

(2) Coated or Impregnated Clay Particles

This main classification of aggregate particles may be said to include those particles which are colored by an impervious colored ceramic surface coating, such as a glaze or slip, or by a water-soluble ceramic coating which penetrates into the clay body to color the particle throughout or nearly so.

The particle may be coated with the glaze or slip by dipping in the color coating or by spraying.

After the coating has dried, the particles are ready for firing. The firing operation must prevent or reduce to a minimum the sticking of particles. Thus far the rotary kiln, rotated at a critical speed and inclined at an angle found by trial to be the most successful, presents the best solution.

There are several disadvantages to the use in concrete of colored aggregate coated by slip or glaze coatings: (1) surface-coated particles are subject to peeling, cracking, and crazing; (2) it is difficult to keep the coated particles from sticking during fusion; and (3) concrete aggregates are subjected to considerable abrasive action during the mixing in the conventional concrete mixer, thereby causing chipping of the particle.

Clay aggregate colored integrally by the impregnation of a water-soluble glaze is both satisfactory and highly practical. This process results in an aggregate particle which is colored throughout the greater portion of its mass.

The study of aggregates of this type was based on a ceramic body identical to that found most suitable for the porcelain-type aggregates. This formula was selected because it gave a sound base which, when fired, produced durable, white, vitreous aggregate of a pleasing surface texture and the white color was essential to the production of clear, well-defined colors.

Two methods of manufacture are available.

The ceramic body, after drying, is crushed but not screened and fired to partial vitrification at 1650°F. The aggregate particles are immersed in, or sprayed with, the water-soluble glaze solution.[5] When cool they are refired to vitrification, the final temperature in this investigation being cones 4 to 5. The final operation is the screening and grading of the aggregate particles into the various size classifications.

In practical operation, this process could be carried out by using rotary kilns. The clay particles may be discharged from a rotary kiln at 750°F into a tank of glaze solution, from where particles could be put through another kiln, firing them to vitrification.

The second method of manufacture is identical to the first except that the crushing of aggregate particles is accomplished after the initial firing

[3] Supplied by Paul Uhlich & Co.
[4] Supplied by Penn Products Corp., Harrisburg, Pa.
[5] Repeated tests indicate 750°F to be the minimum immersion temperature at which satisfactory penetration could be obtained.

to 1650°F. This method is less practical owing to the necessity of reheating the crushed material to 750°F after crushing and thereby involving the expense of an additional firing operation.

It was at first thought possible to use water solutions of metallic salts, but experiments proved this method to be too costly. It was then conceived that deeper colors could be imparted to the metallic salts by precipitating them as carbonates within the particle structure, making it possible to use metallic salts of lower concentration. This idea was tried out by immersing the particles, after partial vitrification, in a saturated solution of Na_2CO_3. The aggregate particles were then reheated to 750°F, immersed in the metallic salt solution, and fired to vitrification. The results indicated that, in drying out, all of the Na_2CO_3 was recrystallized on the surface of the particle, giving a crystalline surface coating deeper in color than the inside of the particle. A glaze was then made of water-soluble components, which would penetrate into the particle and yet produce a surface glaze which would not cover or destroy the surface characteristics of the aggregate itself. The possibility of using a smaller amount of metallic salt, owing to the fusion of the glaze, was also considered. From the 108 separate formulas investigated, the glaze formula given below was considered the most successful because the particle was uniformly colored, the surface coating of the particle was impervious, and the use of costly metallic salts was reduced to a minimum.

Glaze formula	Percentage by weight
Aluminum chloride	60.0
Magnesium chloride	20.0
Sodium chloride	10.0
Borax	10.0
	100.0

Colorants

Color	Coloring agent
Dark blue	25% cobalt chloride
Light blue	10% " "
Dark green	25% chromic nitrate
Light brown	11% ferric chloride
Brown-red	20% " "
Metallic brown	25% cupric chloride

The glaze was prepared by dissolving the components in water in the ratio of 100 grams of dry chemicals per 400 cubic centimeters of water. By actual trial, it was found that from 110 to 144 pounds of dry chemicals were required to color a ton of clay aggregate.

(3) Glass Aggregate

The utilization of colored glass as concrete aggregate involves no new principle or idea. The use of glass as aggregate is highly desirable and satisfactory where the color and finish must be brilliant. The ease with which such a surface may be cleaned is an advantage not to be minimized.

It is necessary that the glass aggregate produced should be sound (this prevents the consideration of any process such as water-chilling due to the fragile particles produced) and it should be opaque to impart color to the concrete and to provide an aggregate surface capable of maximum light reflection.

In the laboratory where the glass aggregate batches were formulated and prepared, the procedure was as follows: After thorough mixing, the raw materials were placed in a crucible or pot having a capacity of 60 pounds of glass per charge and fused at a temperature of 2200°F. The fining operation was relatively short in duration, as it was believed that the presence of fine bubbles or seeds would not be detrimental in the large irregular masses of glass produced. After fusion and fining, the glass was ladled out on a steel plate in large circular masses to a thickness of approximately two inches. The thickness of this poured glass mass is important only in that it should be of such dimension as to prevent the formation of glass slivers after crushing. When the poured glass was cool, it was crushed, screened, and graded into the mesh classification previously given. The tendency to break into sliver-like particles makes the use of an impact crusher absolutely necessary.

In presenting representative glass batches formulated during this investigation (Table II), the amounts of basic raw materials are recalculated to total 100%. Color additions are expressed in terms of percentage of the total raw material weight.

It should be emphasized that considerable work is contemplated and should be done on the investigation of other glass-batch components in order to reduce the cost of glass aggregate. The use of opal-glass cullet as a glass-aggregate base is worthy of consideration and study.

TABLE II

GLASS BATCHES IN WEIGHT PERCENTAGE

Color	Green	Violet	Blue	White	Black	Red	Orange	Yellow
Sand	56.1	56.1	56.1	54.5	59.4	58.0	58.0	58.0
Soda ash	23.5	23.5	23.5	22.8	24.0	17.3	17.3	17.3
Feldspar	6.1	6.1	6.1	5.95	6.2			
Lime	6.1	6.1	6.1	5.95	10.4			
Fluorspar	8.2	8.2	8.2	7.9				
Cryolite				2.9		3.8	3.8	3.8
Zinc oxide						20.9	20.9	20.9
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Copper oxide	1.02		1.53					
Potassium bichromate	1.02							
Cobalt oxide			0.1					
Manganese dioxide		1.53			2.08			
Iron oxide					2.08			
Selenium						0.92	0.41	
Cadmium sulfide						1.02	1.02	1.02

IV. The Use of Ceramic Aggregate in Concrete

In the concrete mix, colored ceramic aggregate is substituted for sand and gravel. Its use has been limited to the facings of concrete masonry and precast concrete units. The application of colored concrete facings to vertical surfaces and the pouring of these facings in monolithic concrete construction is to be attempted.

FIG. 1.—Pictorial effect executed in colors by using colored ceramic aggregate in concrete.

The thickness of the colored facing on precast units is governed somewhat by the practice of individual manufacturers. In the fabrication of samples and precast units in the course of this investigation, a facing of approximately $^3/_8$ inch was used.

The ratio of cement to aggregate is governed by the quality of mix and distribution of the aggregate being sought. The use of a cement pigment is dependent upon the color effect desired.

The combination of sizes of ceramic aggregate is dependent upon the finish and surface texture used and varies with the method of manufacture, *i.e.*, whether by mechanical molding, hand-puddled, or dry-tamped.

If a rough, exposed aggregate surface is desired, the surface of the piece is thoroughly wire-brushed as soon as possible after molding to remove all cement from the face and sides of the aggregate particles. If the aggregate surface is to be merely exposed, a light brushing will be sufficient. After thorough curing and drying, washing with a dilute solution of hydrochloric acid intensifies the color effect. A polished surface may be produced by honing or grinding after the unit is thoroughly cured.

Figures 1 and 2 indicate interesting results possible with this material.

V. Test on Finished Product

Over an extended freezing and thawing test totaling 200 cycles, where cement, aggregate, and water content were constant, the ceramic aggregate compared favorably with sand and gravel specimens. The specimens tested were 2- by 2- by 10-inch prisms equipped with stainless steel reference points for measuring linear expansion. The freezing and thawing temperatures covered a range from 20° to 80°F. The specimens were in the freezing cycle for a period of 22 hours, and during that time were subjected to temperatures below zero for a period of 7 hours. Thawing was accomplished in 2 hours by submerging in a tank of water kept constant at 80°F by automatic thermostatic control. Linear expansions were measured on the comparator at a constant temperature of 80°F. These readings and the loss in weight were recorded after every 10 cycles.

FIG. 2.—Geometrical design ornament executed in colored concrete.

Type of aggregate	Linear expansion(%)	Weight loss(%)
Sand and gravel	0.059	3.20
Porcelain type	0.063	3.73
Glass	0.075	4.76

NOTE: Linear-expansion percentage is expressed in terms of length after 14-day curing. Weight-loss percentage is expressed in terms of weight after 14-day curing.

Specimens similar in all respects to those used in the freezing and thawing tests were made for strength tests. These specimens were cured in water for 28 days before testing. The 2- by 2- by 10-inch specimens were tested for flexural strength on a cross-breaking machine having an 8-inch span. The broken halves from the flexural test were tested for compressive strength on a 75,000 pound hydraulic testing machine. The comparative average results were as follows:

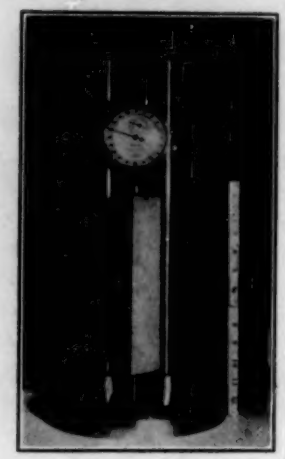

FIG. 3.—Comparator for measuring linear expansion.

Type of aggregate	Modulus of rupture (lb./sq. in.)	Compressive strength (lb./sq. in.)
Sand and gravel	1045	8340
Porcelain type	1065	8200
Glass	735	6930

Lower strength results with the glass aggregate are not necessarily indicative of a lower strength of the glass aggregate itself. It serves to indicate a somewhat lower bond between the cement paste and the glass aggregate due to its natural smooth and glossy texture.

Although these limited physical tests are not conclusive proof that colored ceramic aggregate is suitable for use in concrete, they serve to substantiate the excellent service record of structures in which this material has already been used. Durability, a wide range of possible colors, and greater flexibility in use are factors which favor ceramic materials as a solution to colorful and decorative effects in concrete.

Acknowledgments

Acknowledgments are made for the administrative direction of this investigation by Frank T. Sheets, Director of Development, and A. J. Boase, Manager, Structural and Technical Bureau of the Portland Cement Association. Incorporation of ceramic aggregate into concrete was done with the assistance and advice of C. G. Walker, Secretary of the Cast Stone Institute. Appreciation is expressed to Thomas C. Thompson, Wilmette, Illinois, for assistance rendered in the formulation and fabrication of glass aggregate batches.

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CERIUM OXIDE AND RARE EARTH OXIDE MIXTURE IN GLAZES*

BY BYRON W. MERWIN

ABSTRACT

The object of this investigation was to determine the effect of various RO combinations on the opacifying properties of cerium oxide and a rare earth oxide mixture and their effect on the common coloring oxides.

I. Introduction

It was thought that cerium oxide or a rare earth oxide mixture could possibly be used to produce a glaze that would be unusual enough to warrant the otherwise prohibitive cost of these oxides. Cerium oxide can be used as an opacifier in a glaze[1]; the large amount needed, however, is prohibitive because of its high cost.

The materials used in this investigation were (1) cerium oxide with a CeO_2 content in excess of 99%, and (2) a rare earth oxide mixture which was a pure oxide mixture containing the rare earths, cerium oxide 50%, lanthanum oxide 20%, neodymium oxide 20%, and praseodymium and samarium oxides 10%.

The body used was a white earthenware, cast and bisque-fired to cone 9 in 12 hours.

II. Method of Procedure

(1) Cerium Oxide Glazes

Five series of glazes were made.

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, March 31, 1936 (White Wares Division). Received March 31, 1936.

[1] B. W. Merwin, "Ceric Oxide as New Opacifying Agent," *Ceram. Ind.*, **24** [4] 214 (1935); *Ceram. Abs.*, **14** [6] 149 (1935).

Series C-1: The base glaze composition was as follows:

$$\left.\begin{matrix}PbO\ 0.46\\CaO\ .31\\K_2O\ .22\end{matrix}\right\}\ Al_2O_3\ 0.33\ \ [SiO_2\ 1.98$$

A straight-line blend was made with this base glaze plus 0.15 equivalent of cerium oxide.

Series C-2: The base glaze of this series was as follows:

$$\left.\begin{matrix}PbO\ 0.44\\CaO\ .30\\ZnO\ .10\\K_2O\ .16\end{matrix}\right\}\ Al_2O_3\ 0.30\ \ [SiO_2\ 2.00$$

A straight-line blend was made between this glaze and the same glaze with an addition of 0.15 equivalent of cerium oxide.

Series C-3: The formula of the base glaze for this series was the same as series C-2, using BaO rather than ZnO.

Series C-4: The base glaze was of the following composition:

$$\left.\begin{matrix}PbO\ 0.40\\CaO\ .40\\K_2O\ .10\\Na_2O\ .10\end{matrix}\right\}\ Al_2O_3\ 0.30\ \ \left\{\begin{matrix}SiO_2\ 2.80\\B_2O_3\ 0.20\end{matrix}\right.$$

This blend was made between this glaze and the same glaze with an addition of 0.15 equivalent of cerium oxide to determine the effect of boric acid on the opacifying properties.

Series C-5: Cerium oxide was substituted for the CaO in the base glaze of series C-2 as one end member. The other member of the blend was the base glaze used in series C-2.

(2) Rare Earth Oxide Mixtures

Series R-1 to R-5 (inclusive): This series was the same as the respective glazes of series C except that the rare earth oxide mixture was substituted for the cerium oxide in each case.

(3) Rare Earth Oxide and Alkaline Base Glaze

Series R-6: In this series the rare earth oxide mixture was added to a highly alkaline base glaze; the formula was as follows:

$$\left.\begin{matrix}PbO\ 0.40\\CaO\ .30\\K_2O\ .15\\Na_2O\ .15\end{matrix}\right\}\ Al_2O_3\ 0.30\ \ \left\{\begin{matrix}SiO_2\ 2.80\\B_2O_3\ 0.30\end{matrix}\right.$$

This base glaze was used as one member of the blend and also, with an addition of 0.15 equivalent of the rare earth oxide mixture, as the other end member.

(4) Decrease in PbO and Al_2O_3 and Increase in CaO and B_2O_3

Series R-7: In this series the effect of decreasing the PbO and Al_2O_3 content with a simultaneous increase in the CaO and B_2O_3 content was determined. One end of the blend was the base glaze used in series R-6. The other end member had the following formula:

$$\left.\begin{matrix}PbO\ 0.20\\CaO\ .40\\K_2O\ .10\\Na_2O\ .30\end{matrix}\right\}\ Al_2O_3\ 0.15\ \ \left\{\begin{matrix}SiO_2\ 2.8\\B_2O_3\ 0.6\end{matrix}\right.$$

Rare earth oxide mixture 0.30.

(5) Cerium Oxide and Rare Earth Oxide Mixtures

K-Series: A series of blends were made to determine the effect of cerium oxide and the rare earth oxide mixture on some of the common coloring oxides. The base glaze selected for this group of blends was the base glaze used in series C-4. In this series the amount of color oxide was held constant throughout the blend and the amount of cerium oxide and the rare earth oxide mixture was increased at 20% intervals from 0.0 to 0.15 equivalent.

Series N-1 to N-8 (inclusive): The glazes of this series were the same as the respective members of the K-series except that the rare earth oxide mixture was substituted for the cerium oxide.

(6) Crystallizing Effect of Rare Earth Oxides

Two blends were made to determine the crystallizing effect of the rare earth oxide mixture on the glaze.

Series A-1: A high zinc glaze of the following formula was made:

$$\left.\begin{matrix}Na_2O\ 0.30\\K_2O\ .08\\ZnO\ .63\end{matrix}\right\}\ Al_2O_3\ 0.13\ \ \left\{\begin{matrix}SiO_2\ 2.22\\B_2O_3\ 0.30\end{matrix}\right.$$

This glaze was used as one end member of the blend and also with 0.45 equivalent of the rare earth oxide mixture as the other member.

Series A-2: The following glaze of lower ZnO content than series A-1 was blended the same as series A-1:

$$\left.\begin{matrix}K_2O\ 0.07\\Na_2O\ .20\\PbO\ .13\\ZnO\ .33\\CaO\ .27\end{matrix}\right\}\ Al_2O_3\ 0.12\ \ \left\{\begin{matrix}SiO_2\ 2.00\\B_2O_3\ 0.40\end{matrix}\right.$$

All of the glazes were fired to cone 4 in 9 hours in a downdraft, oil-fired test kiln.

III. Results

(1) The composition of the RO group had little to do with the opacifying properties of cerium oxide.

(2) Cerium oxide decreases crazing.

(3) CeO_2 could not be introduced into a glaze in place of the CaO. The glaze without CaO had to be fired at cone 9 before it matured. The cerium oxide tended to increase the refractoriness of the glaze, and this effect was found in all blends.

(4) The rare earth oxide mixture was a more refractory glaze material than the cerium oxide but its opacifying property was less.

(5) The rare earth oxide mixture affected the glaze in the same manner as did the addition of calcined alumina.

(6) All members of series R-1 to R-7, inclusive, showed a tan color of a varying shade. Variation of the RO composition did not have any effect on the tone of the color produced but B_2O_3 addition tended to bleach it.

(7) Series K-1[1] (0.08 equivalent CuO): The base glaze with copper was a pleasing green and the glaze with the maximum cerium oxide and copper oxide was a light turquoise. The glaze was made up of small green spots beneath the surface on a light turquoise background giving the pleasing effect which artists define as "texture." This texture remained even though the glaze had a perfectly smooth surface.

(8) Series K-2 (0.10 equivalent Cr_2O_3): The base glaze with chromic oxide was a chrome green, whereas with the cerium oxide added it was a semimat green of a lighter tone.

(9) Series K-3 (0.05 equivalent MnO_2): No very good results were obtained with manganese.

(10) Series K-4 (0.05 equivalent CoO): The ordinary run of cobalt blues was obtained; the tones graded from a dark blue to a powder blue as the amount of cerium oxide increased.

(11) Series K-5 (0.10 equivalent NiO): The usual nickel brown given by a glaze of this character was obtained and cerium oxide did not affect the color appreciably.

(12) Series K-6 (0.10 equivalent uranium): With 0.12 equivalent of cerium oxide present, a good green was obtained as a background for small yellow-green spots; 0.15 equivalent of cerium oxide produced a blue-black color.

(13) Series K-7 (0.10 equivalent Fe_2O_3): The usual colors given by ferric oxide were observed.

(14) Series K-8 (10% chrome-tin pink stain): Some good pinks were obtained in this blend. They graded from a strong pink with no cerium present to a pastel pink with 0.15 equivalent. The pastel pink had a desirable semimat texture. The color in all samples of this series was solid.

(15) Series N-1 to N-8: The same texture and series of colors were obtained with rare earth oxide as with cerium oxide although they were somewhat darker in tone. The rare earth oxide mixture was more refractory than the cerium oxide.

(16) In the blends for determining the crystallizing properties of the rare earth oxide mixture, the crystals which were in the base glaze disappeared with an addition of the rare earth oxide mixture to the glaze.

[1] See Section 5, K-series.

Acknowledgment

The author wishes to acknowledge his indebtedness to Paul E. Cox, Head of the Department of Ceramic Engineering at Iowa State College, under whose supervision this investigation was carried out. Thanks are also due to the Lindsay Light and Chemical Company, Chicago, Ill., for supplying the cerium oxide and hydrate and the rare earth oxide and hydrate mixtures used in this investigation.

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Compiled by the
AMERICAN CERAMIC SOCIETY

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Abrasives

Color of corundum. I. I. Islamov and I. M. Tolmachev. *Compt. Rend. Acad. Sci. U.R.S.S.*, [N.S.] **1** [1] 11–13 (1936).—Spectrographic analyses of Semiz-Bugu corundum showed that the red coloring of corundum is caused by chromium and the blue coloring by titanium. A brownish shade of red corundum is perhaps due to iron. Data on quantitative determinations of Cr, Ti, V, and Ga and qualitative determinations of disthene and several other admixtures are given. P.B. & E.S.

Grinding cobalt wire to a diameter of one-half millimeter. O. S. Marshall. *Machinery* [N. Y.], **42** [7] 466 (1936).—A wire 0.5 mm. in diameter by 23 mm. long was ground accurately in a lathe-type grinder from a $^{3}/_{32}$-in. square cobalt bar $1^{1}/_{2}$ in. long. The ends of the bar were hand ground to a conical shape with a 60° included angle. The bar was then held at one end in a small drill chuck secured in the regular 3-jaw chuck of a universal tool-grinder while the opposite end was supported by a recessed center held in the grinder tailstock. The bar was adjusted until it ran approximately true. A wheel with a $^{1}/_{16}$-in. grinding face performed the cylindrical grinding operation, care being taken to grind the bar parallel within 0.001 in. The conical center and untouched portion at the chuck end were ground away and the remaining cylindrical end held in a collet made for the purpose and clamped to it by a setscrew. Care was taken to insure true running of the collet. A spring support with a 60° groove as a saddle to support the wire during the final grinding operation was devised. The wire, was supported by the saddle and the end in the collet, was ground to within 0.0005 in. of the required size. Finally, it was brought to the exact size and given the required finish with a fine-grain oilstone using an accurate flat-surfaced bar as a support along the length of the wire. This bar was adjusted to support the wire from the underside while running the work at top speed. The wire was supported at both ends during this final operation. Illustrated. J.L.G.

Method for obtaining perfectly polished metal surfaces. P. Jacquet. *Compt. Rend.*, **201**, 1473 (1935); abstracted in *Current Sci.*, **4** [8] 605 (1936). D.B.

Polishing of metals. E. J. Dobbs. *Metal Ind.* [London], **48** [8] 234–36, 241 (1936).—The most modern practice, both manual and automatic, of polishing metals is described. Both polishing and grinding concern the abrasion of metal surfaces, and it is difficult to define where one begins and the other leaves off. The first is a simple cutting operation, while the second combines cutting with burnishing as the pressing down of the ridges into the hollows. The abrasives used in grinding and polishing are discussed. Illustrated. H.E.S.

BULLETIN

Abrasive materials. Bertrand L. Johnson and A. E. Davis. Reprint from U. S. Bur. Mines Minerals Yearbook, 1936. Supt. of Documents, Govt. Printing Office, Washington, D. C. 17 pp. Price 5¢. R.A.H.

PATENTS

Abrading machine. G. T. Johnson. U. S. 2,064,476, Dec. 15, 1936 (July 25, 1931).

Abrasive articles. W. J. Tennant (Carborundum Co.). Brit. 456,985, Dec. 2, 1936 (May 18, 1935).

Abrasive devices. Carborundum Co. Brit. 456,904, Dec. 2, 1936 (May 21, 1934).

Automatic cylinder grinder. M. C. Hutto (Carborundum Co.). U. S. 2,063,931, Dec. 15, 1936 (Dec. 24, 1925).

Composite grinding wheels and methods of making. Norton Grinding Wheel Co., Ltd. Brit. 456,950, Dec. 2, 1936 (Feb. 14, 1935).

Cylinder grinder. M. C. Hutto (Carborundum Co.). U. S. 2,063,932, Dec. 15, 1936 (March 4, 1926).

Drill-grinding mechanism. C. E. Young. U. S. 2,065,847, Dec. 29, 1936 (Feb. 27, 1932).

Grinding machine. John Edgar (Barber-Colman Co.), U. S. 2,067,178, Jan. 12, 1937 (Oct. 24, 1932). Willetts Peaslee, L. F. Nenninger, and E. G. Roehm (Cincinnati Grinders, Inc.), U. S. 2,065,151, Dec. 22, 1936 (Aug. 10, 1934). Millard Romaine and W. D. Archea (Cincinnati Grinders, Inc.), U. S. 2,065,099, Dec. 22, 1936 (Dec. 19, 1932).

Grinding machine and method. John Edgar (Barber-Colman Co.). U. S. 2,067,177, Jan. 12, 1937 (July 9, 1930; renewed Dec. 12, 1935). A machine for form and relief grinding rotary cutters has generally longitudinally inclined gashes and a plurality of longitudinally spaced annular rows of teeth.

Grinding machinery. Sol Einstein (Heald Machine Co.), U. S. 2,066,677, Jan. 5, 1937 (Oct. 26, 1931). Millard Romaine (Cincinnati Grinders, Inc.), U. S. 2,065,100, Dec. 22, 1936 (March 3, 1934).

Grinding wheel. M. B. Lane (Norton Co.). U. S. 2,065,942, Dec. 29, 1936 (March 21, 1936). A grinding wheel comprises an abrasive body cemented rigidly to a backing plate by an intermediate cementitious medium including a layer of vulcanized soft resilient rubber and a layer of converted resinoid between the rubber layer and one of the outer bodies.

Lapping device. C. H. Hellvar (Fafnir Bearing Co.). U. S. 2,065,221, Dec. 22, 1936 (April 11, 1928; renewed Dec. 29, 1932).

Machine for grinding gear wheels. A. H. Orcutt (Gear Grinding Co., Ltd.). U. S. 2,066,220, Dec. 29, 1936 (Oct. 23, 1935).

Machine for polishing, sanding, etc. W. O. Arnold. U. S. 2,067,624, Jan. 12, 1937 (July 18, 1935).

Manufacture of porous bonded abrasive articles. Carborundum Co. Brit. 454,251, Oct. 7, 1936 (March 29, 1934).

Means for sharpening rotary cutting disks. O. Legg. Brit. 454,166, Oct. 7, 1936 (March 29, 1935).

Method of balancing abrasive wheels and wheels thereby balanced. H. R. Simonds (Simonds Worden White Co.). U. S. 20,207, Dec. 15, 1936 (Sept. 24, 1936); reissue of original U. S. 1,975,053, Sept. 25, 1934.

Method of and device for dressing or truing profiled grinding disks for grinding toothed wheels having oblique teeth. Zahnradfabrik Friedrichshafen A.-G. Brit. 454,089, Oct. 7, 1936 (Dec. 22, 1933).

Mounted grinding wheel. M. B. Lane (Norton Co.). U. S. 2,065,941, Dec. 29, 1936 (March 21, 1936). A grinding wheel comprises an abrasive body cemented rigidly to a backing plate by an intermediate cementitious medium including a layer of vulcanized soft resilient rubber and a layer of sodium silicate between the rubber layer and one of the outer bodies.

Pinhole grinder. Joseph Sunnen. U. S. 2,066,586, Jan. 5, 1937 (July 28, 1934).

Pulpstone. Thure Larsson (Norton Co.). U. S. 2,066,629, Jan. 5, 1937 (March 25, 1936).

Saw sharpener. A. C. Elder. U. S. 2,067,179, Jan. 12, 1937 (March 4, 1935).

Truing apparatus for lapping machines. H. S. Indge (Norton Co.). U. S. 2,067,531, Jan. 12, 1937 (April 6, 1936).

Valve-grinding apparatus. A. E. Wood. U. S. 2,066,601, Jan. 5, 1937 (June 21, 1935).

Art and Archeology

Blue John pottery. Anon. *Pottery & Glass Record*, **18** [12] 316, 333 (1936).—Pottery with a mottled or variegated background resembling the famous Blue John stone (a bluish colored fluorspar found in Derbyshire, England) is now made in a variety of colors by E. Lockett & Sons, Stoke-on-Trent. The Blue John fluorspar was carved into vases and other ornaments in the late Georgian and early Victorian periods, and a little is still used for this purpose. The Blue John pottery is a variety of earthenware and only in its background does it bear any resemblance to the fluorspar. A.B.S.

Ceramics in Modena. Adamo Pedrazzi. *Corriere Ceram.*, **17** [10] 285–99 (1936).—P. describes articles of ceramic ware of different prehistoric periods found at Modena, Italy, indicating the clay mixtures, manner of fashioning, forms used, and decoration of the various periods. Etruscan and Roman ceramics and the 14th Century and Renaissance periods are taken up in a similar manner. Majolica of Modena is also discussed. M.V.C.

Decadence of the porcelain of Capodimonte. Ettore Settanni. *Corriere Ceram.*, **17** [10] 305–307 (1936).—Under Carlo III porcelain manufacture in the Neapolitan area reached its most splendid period. With the accession of Ferdinando IV, and later, artisans were brought in from other countries, so that Neapolitan majolica began to lose its original character. With the advent of the French in 1799, activity at the royal factory at Naples definitely declined, and in 1834 the majolica industry ended entirely. M.V.C.

Dinnerware design. Charles H. Oppenheimer. *China, Glass & Lamps*, **56** [5] 30–31 (1937).—Dinnerware history shows that flowers and fruit have predominated for many years. Recently, new design treatments in keeping with modern style trends in industry have been accepted. Decalcomanias are generally used. Several small decals are cheaper than one large one. Designs requiring close matching in application to the ware are more costly. Women generally prefer decorations around the edge of the plate. Abstract designs have a limited sale. Warm, brilliant colors are popular. Successful designs have incorporated early American scenes, sporting events, animals, chintzes, plaids, caricatures, nautical scenes, etc. Designs with insects will not sell. G.M.P.

Joseph Locke, artist. Alexander Silverman. *Glass Ind.*, **17** [8] 272–75 (1936).—A biographical sketch of this master etcher, engraver, and sculptor in glass is presented. Illustrated. E.J.V

Orrefors of Sweden. ANON. *China, Glass & Lamps*, **56** [2] 34–36 (1936).—The Orrefors factory, originally an ironworks and common glass factory, was converted in 1913 to the making of crystal glassware. At first the ware was decorated in the characteristic styles of cut glass. Later, engraving was revived from an almost extinct art in Sweden. Hald and Gaté were the leading artists. They largely produced symbolic feminine figures and abstract themes, engraved with copper wheels. Lundstrand and Landberg were other artists at Orrefors. Much Orrefors glassware is made without ornamentation except as to shape, luster, and delicate colors. It is made entirely by hand. Illuminating glass is also made. Illustrated. G.M.P.

Precious metals as materials for decorating pottery and glass. W. P. HARMSWORTH. *Sands, Clays & Minerals*, **3** [1] 49 (1936).—The rare metals most used are, besides Ag, Au and Pt. Methods of bringing the metal into a form in which it can be applied on the glassware and burnished are described. Although only minute quantities are used on a single piece the total consumption of precious metals for this purpose is considerable, as it can not be recovered. M.H.

Standard colors for houseware. ANON. *China, Glass & Lamps*, **56** [4] 60 (1936).—A group of merchandise managers and buyers was called by the Merchandising Division of the National Retail Dry Goods Assn. to select standard shades of colors and present them to the industry for approval. This would enable a customer to assemble merchandise completely in a standard shade of one color. It would reduce misunderstanding between retailer and manufacturer in placing orders. G.M.P.

Terra sigillata. F. SCHWARZ. *Berg- & Hüttenmänn. Jahrbuch*, **84** [3] 128–31 (1936).—The question of how the ancient (Roman) clay vessels known as sigillata were made is discussed, and, on the basis of chemical composition and firing experiences with different clays, theories are developed according to which a soap-maker by chance found that borax would produce in the fire a glassy-appearing red shard which did not absorb water. It is not an actual glazing, as the body consists only of alumina, and borax was very likely added in some form during the firing process. Firing must have been done at a temperature not higher than 1100°C, as only wood was used as fuel. The silicic acid necessary for forming the glassy-appearing skin on the vessels originates from the disintegration in firing of the silicate $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$ to $Al_2O_3 \cdot SiO_2$ and SiO_2. M.H.

There is nothing new. ANON. *China, Glass & Lamps*, **56** [4] 58–60 (1936).—The manufacture of glass is one of the oldest industrial arts but it is difficult to find a new glassware design. Articles made during the old Roman Empire showing a footed tumbler with enamel decoration, ball stem, and conical foot, a jug similar to Mexican peasant ware, and a beaker blown in a mold are illustrated. A "History of Glass" exhibition at the Metropolitan Museum of Art shows glassware from the 15th Century B.C. to the 20th Century A.D. with amazing similarity of designs from different eras. The oldest dated glassware known is Egyptian from about 5500 B.C. Early glass was shaped over a sand core. Blowing was discovered about 100 B.C. Italy was famous for glassblowing during the middle ages. English craftsmen developed lead glass suitable for deep cutting. American inventiveness contributed the pressing machine. G.M.P.

PATENTS

Designs for:

Bathtub. W. J. KOHLER AND G. K. GEERLINGS. U. S. 102,370, Dec. 15, 1936 (Sept. 5, 1936). U. S. 102,558, Dec. 29, 1936 (Aug. 31, 1936). U. S. 102,559, Dec. 29, 1936 (Sept. 2, 1936).

Bottle. S. S. FREEDMAN (Kolmar, Inc.), U. S. 102,420, Dec. 22, 1936 (Sept. 17, 1936). B. D. FUERST (Owens-Illinois Glass Co.), U. S. 102,422, Dec. 22, 1936 (Nov. 10, 1936). FRANK MCLAUGHLIN (Carr-Lowrey Glass Co.), U. S. 102,636, Jan. 5, 1937 (Nov. 10, 1936). F. J. PETTY (Ball Brothers Co.), U. S. 102,444, Dec. 22, 1936 (Nov. 6, 1936).

Bowl. J. E. SPENCE (Hazel-Atlas Glass Co.). U. S. 102,457, Dec. 22, 1936 (Oct. 19, 1936).

Cup. S. E. THOMPSON. U. S. 102,458, Dec. 22, 1936 (April 8, 1936).

Fish jar. M. S. DESSER AND E. W. FUERST (Owens-Illinois Glass Co.). U. S. 102,550, Dec. 29, 1936 (Nov. 10, 1936).

Jar. FRASIER SMITH (Hazel-Atlas Glass Co.). U. S. 102,456, Dec. 22, 1936 (Aug. 15, 1936).

Lighting-fixture bowl. NICHOLAS KOPP (Kopp Glass, Inc.). U. S. 102,560, Dec. 29, 1936 (Oct. 17, 1936).

Plate. ANTON ECKERT. U. S. 102,356, Dec. 15, 1936 (Sept. 23, 1936). J. E. SPENCE (Hazel-Atlas Glass Co.), U. S. 102,658, Jan. 5, 1937 (Nov. 2, 1936).

Strainer. M. H. CONNOR (Owens-Illinois Can Co.). U. S. 102,413, Dec. 22, 1936 (Sept. 30, 1936).

Teacup. KARL BAYREUTHER (Rosenthal China Corp.). U. S. 102,350, Dec. 15, 1936 (Sept. 25, 1935).

Cements

Admixtures of Portland cement: I. M. ONO. *Jour. Soc. Chem. Ind. Japan*, **39** [10] 365–66B (1936).—On investigating the peculiar absorptive phenomena of admixtures of Portland cement produced in Japan and Manchuria, O. found (1) that the early absorptive phenomenon of lime is mainly due to physical absorption, and (2) that the slow absorption in a later period, of long duration, differs entirely from the early absorptive phenomenon and is due to the chemical combination. M.V.C.

Behavior of lime silicates and lime aluminates with water solutions. R. NACKEN. *Zement*, **25** [34] 565–70; [35] 583–87 (1936).—N. investigated, at 30°C, systems containing water according to the principles of heterogeneous equilibria. In the system CaO–Al_2O_3–H_2O, he found stable and unstable equilibria including $3CaO \cdot Al_2O_3 \cdot 6H_2O$; $Ca(OH)_2$; $4CaO \cdot Al_2O_3 \cdot 13H_2O$; $2CaO \cdot Al_2O_3 \cdot 7H_2O$. The last compound is intermediary and postpones true equilibria. The system $CaCl_2$–$3CaO \cdot Al_2O_3$–H_2O was treated as ternary. The influence of $CaCl_2$ upon $3CaO \cdot$

SiO_2 is practically nil. Heats evolved by $3CaO \cdot Al_2O_3$ in the presence of water or solutions were registered by curves. N. concludes there is first a hydrolysis and, after a few minutes, formation of lime aluminate hydrates. F.E.V.

Bound water in hardening cements and frost resistance of cement mortars. H. E. VON GRONOW. *Zement*, 25 [29] 485–90 (1936).—G. discriminates between bound water retained after one hour's heating at 110°C and free water eliminated during this heating. Gels and "free" water form unstable compounds disintegrating below 100°C. At low temperature, these compounds are stable enough to prevent frost. The crystallization velocity of water is high, but its crystallization power is very small (Tammann). G. describes a special dilatometer to measure free water and frost expansion. Resistivity against frost is beyond expectation. G. discusses the use of $CaCl_2$ for concrete works in winter. F.E.V.

Calcium aluminates: VI, Hydration of tricalcium aluminate. SEIJI KONDO AND TOSHIYOSHI YAMAUCHI. *Jour. Japan. Ceram. Assn.*, **44** [521] 316–22 (1936).—Corrections and a supplement are given to Part III of the series (*Ceram. Abs.*, **12** [4] 141 (1933)) as follows: (1) With a water-cement ratio of 1 and more as in the experiment of Part III, the uniaxial optically positive crystals, *A*, whose ω_D and ϵ_D are 1.498 and 1.507, respectively, are produced in the earliest period. They change before long to the hexagonal uniaxial negative crystals, *B*, whose ω_D and ϵ_D are 1.524 and 1.506, respectively. The uniaxial negative crystals, *C*, which are produced in the later periods and whose ω_D and ϵ_D are 1.535 and 1.511, respectively, are small in quantity. Thus the *B* crystals play the most important rôle and are the chief product in the hydration with much water. (2) With water-cement ratios less than 1, crystals quite different are produced as the ratio decreases. Instead of the *B* crystals, minute grains or fibers of regular system, with n_D of 1.604, are formed. (3) The lattice constant of the regular crystals is about 12.454 Å. They suffer no structural change even on standing for 35 days. S.K.

Chemical constitution of Portland cement and the development of its technical properties. MICHEL J. M. JASPERS. *Rev. Matériaux Construction Trav. Publics*, No. 325, pp. 224–26; No. 326, pp. 255–59 (1936).—In reality a Portland cement is not a ternary system, but if one takes into account the presence of Fe_2O_3 and disregards the small amount of secondary elements, it can be considered as a quaternary system formed of CaO, SiO_2, Al_2O_3, and Fe_2O_3, constituting 95 to 97% of the mass. Quaternary forms are studied and a detailed exposition of the system $CaO–C_2S–C_3A_2–C_4AF$ is given. See *Ceram. Abs.*, **16** [2] 56 (1937). M.V.C.

Corrosion of pozzolana conglomerates. G. MALQUORI. *Ricerca Sci.*, 2 [7–8] 440–42 (1936).—Recent literature on the fixing action for lime exercised by good pozzolana materials is discussed. M.V.C.

Differences in limes as reflected in certain properties of masonry mortars. LANSING S. WELLS, DANA L. BISHOP, AND DAVID WATSTEIN. *Jour. Research Nat. Bur. Standards*, **17** [6] 895–907 (1936); R.P. 952, Price 5¢.—A survey was made of the soundness and plasticity of lime putties made from 43 commercial limes, including pulverized quicklimes and hydrated limes. R.A.H.

Laboratory cements and waxes. L. WALDEN. *Jour. Sci. Instruments*, **13** [11] 345–52 (1936).—W. considers the properties and uses as cements and waxes of (1) sealing wax, (2) shellac, (3) Apiezon wax "W," (4) Dekhotinsky cement, (5) Picien cement, (6) beeswax and rosin, (7) soft red wax (yellow beeswax, turpentine, and Venetian red), (8) glue and treacle, (9) marine glue or Chatterton's compound (shellac and caoutchouc), (10) lead oxide aquaria cements (3 parts red lead, 1 part white lead, and 30 cc. linseed oil per pound of oxides), (11) other lead base mixtures such as red lead and glycerine, litharge and glycerine, lead oxides and sodium silicate, and lead oxides and linseed oil-rosin mixtures, (12) Bakelite cement, and (13) Insa-lute cement. 1 table. J.L.G.

Lime content and resistivity of cement against chemical attack. V. RODT. *Zement*, 25 [28] 469–71 (1936).—The better resistance of slag cements is due to lower free lime content after hardening. Lime silicate and lime aluminate are practically indifferent to water. R. determined bound water and free lime in different cements after protracted exposure to water. Blast-furnace slag does not evolve free lime. In the mixtures of Portland cement and slag, the quantity of bound water is high when the hydrolysis of Portland cement is intense; the emission of free lime by the Portland component is stronger than in pure Portland cements. F.E.V.

Mining and treating of gypsum. F. GREGOR. *Tonind.-Ztg.*, **60** [82] 1012–14; [83] 1030–32 (1936).—German gypsum deposits and their mining are briefly discussed. The working and treating of gypsum are dealt with. Illustrated. M.V.C.

PATENT

Cement for metallic and ceramic constructional parts. ARTUR MÖHRLE (Robert Bosch A.-G.). U. S. 2,065,389, Dec. 22, 1936 (May 22, 1935). A cement for joining ceramic and metallic materials consists of a mixture with concentrated water-glass solution of 95 to 99.8% of finely divided alumina and 0.2 to 5% of a silicofluoride.

Enamel

Adherence of ground enamels containing cobalt and nickel oxides. FRIEDRICH HEIMES. Translated in *Ceram. Age*, **26** [5] 180–82 (1935); for abstract see *Ceram. Abs.*, **14** [9] 210 (1935). F.G.H.

Advantages of electric furnaces for enameling. OTTO JUNKER. *Emailwaren-Ind.*, **13** [39] 319–21 (1936).—Data on the consumption of electrical current and its dependence on various factors are given. M.V.C.

Bath of adhering oxides for sheet-iron enamels. ANON. *Glashütte*, **66** [35] 606–608 (1936).—Attempts to use solutions of cobalt or nickel salts, in which the ware is immersed before enameling, to promote the adherence of the enamel are discussed with special regard to American studies. Two German patents dealing with the same subject are discussed. M.V.C.

Blast cleaning. EDWARD VAN DER PYL AND HAROLD

HOLDEN. *Enamelist*, 13 [12] 27–30 (1936).—In the preparation of surfaces of iron castings for vitreous enamel, the surface must be clean and roughened sufficiently to provide a measure of mechanical bond between the iron and the porcelain enamel. After grease and oil have been removed from castings by washing or by annealing, blast cleaning effectively removes the scale, corrosion, sand, and other foreign matter and at the same time provides a roughness, the degree of which depends on the method used. In wheel-blast cleaning the abrasive velocity is developed by a simple paddle wheel, the abrasive being thrown out at the periphery. This method is applied to small castings or castings that can be handled in the ordinary barrel or table. In air-blast cleaning the abrasive is mixed with compressed air and blown through a nozzle onto the work. Abrasives used are sand, chilled shot, and angular chilled shot. Sand is highly efficient but is being legislated out of use. Next to compressed air, the most important factor in air-blast cleaning is the nozzle, as it definitely controls abrasive velocity, stream concentration, and abrasive delivery per cubic foot of air consumed at a given pressure. Data on tests which undertook the measurement of air consumption, abrasive delivery, abrasive particle velocity, stream concentration, and work done are presented. Illustrated. E.J.V.

Borax as an addition to the mill. VIELHABER. *Emailwaren-Ind.*, 13 [45] 363–65 (1936).—The solubility of borax in water in dependence on temperature is discussed. M.V.C.

Coat enamels poor in borax. VIELHABER. *Emailwaren-Ind.*, 13 [48] 387–88 (1936).—Because of the necessity of importing borax from abroad, attempts in Germany to use less of it in enamels are discussed. It is possible to lower the borax content 2% in coat enamels when using soda and potash as flux, without impairing the quality. See "Borax—" *Ceram. Abs.*, 15 [11] 324 (1936). M.V.C.

Drying and heating equipment for porcelain enamelware. CARL F. MAYER. *Enamelist*, 14 [1] 27–31 (1936).—M. points out the advantages of a portable-type steel-insulated panel construction drier. The development and application of the "air-heater principle" has made obsolescent the former methods of heating the drier. The air-heater principle simply invokes the use of volumes of heated air, the amount depending on the B.t.u. input required by the drier. Development of the direct fuel-fired air heater has made possible the use of a "convection" principle which gives greater temperature uniformity, faster drying, fuel economies, and the possibility of cleaning and conditioning the air. Illustrated. E.J.V.

Drying porcelain enamels. R. R. SHERRILL. *Enamelist*, 13 [12] 7–11 (1936).—Fundamentally, the drying process is a change of state of water from liquid to vapor. The evaporation of water is explained according to the kinetic-molecular theory, and S. shows how temperature, humidity, and air currents affect the evaporation. With a knowledge of the mechanics of drying, many drying difficulties can be solved. A drier must provide for the proper drying of the enamel and must be sized correctly for the amount of ware to be dried. Types include room driers, conveyer type drier using chain conveyers or laydown cable conveyer, and steam coil benches or the register type. The various types are discussed briefly. E.J.V.

Effect of low temperature on tensile impact resistance of iron, steel, and welded joints. OTTO H. HENRY. *Welding Jour.* [N. Y.], 15 [10] Supp. pp. 2–9 (1936).—H. discusses results from a large amount of data presented in numerous curves and tables for tensile-impact properties of gas-welded Armco, 0.25 C, 0.85 C, and 18–8 steel, arc- and gas-welded and brazed under various conditions. Tests were made at room temperature down to −80°C. No relation is evident between the notch impact values of welds and tensile impact. Bibliography. W.H.B.

Enamel for the chemical industry. ANON. *Glashütte*, 66 [48] 809–11 (1936).—The composition and properties of cast-iron and sheet-iron enamels and their use in the chemical industry are dealt with. Tables with enamels alloys, and glass syntheses are given. M.V.C.

Exposure tests on architectural porcelain enamels. M. G. AMMON. *Enamelist*, 14 [3] 7 (1936).—Test panels of different types of porcelain enamels were placed in an atmosphere normal for a city residential district, facing south and inclined at approximately a 45° angle, so as to receive as much sunlight as possible. After four years of exposure the panels were cleaned and inspected. The glossy acid-resisting enamels and high-fired sign enamels are generally the best type for architectural purposes or for any product exposed to the outdoors. The mat-finish, non-acid resisting enamels which have been used most prominently for architectural purposes weather badly. This is probably due to their slight porosity. E.J.V.

First porcelain enamel residence after four years. ANON. *Enamelist*, 14 [2] 24–25 (1936).—A check on the porcelain enameled house erected in 1932, in South Euclid, Ohio, resulted in a satisfactory report. No signs of deterioration in the porcelain enamel materials are in evidence, the exterior colors looking as fresh as the day the house was erected and rain being the only cleaning agent. E.J.V.

Fishscales. VIELHABER. *Emailwaren-Ind.*, 13 [46] 371–72 (1936).—V. discusses articles on the formation of fishscales (*Ceram. Abs.*, 12 [4] 143 (1933); 15 [8] 230 (1936)). M.V.C.

Fluorspar. VIELHABER. *Emailwaren-Ind.*, 13 [40] 326–27 (1936).—The variation in the composition of fluorspar used for enamels is discussed. M.V.C.

Foundry practice and methods of control of cast iron for porcelain enameling. R. B. SCHAAL. *Enamelist*, 14 [1] 18–26 (1936).—As leadless enamels are coming into greater application on cast-iron enameled parts, attention must be given to the type of cast iron used as well as the leadless enamel. Certain basic ideas have been well established which, if applied and rigorously controlled, will improve the quality of castings produced and tend toward uniformity, thus making enameling much easier and less costly. Desirable qualities and control of the raw materials, pig iron, foundry returns, scrap, coke, limestone, and miscellaneous fluxes are discussed. The cupola furnace and auxiliary melting equipment, with features considered essential for reasonable control of the melting operation, are listed. Principles to be observed in connection with metallurgical considerations are taken up. For porcelain enameling purposes, the structure of the

casting should be mainly pearlitic, and should show some ferrite. For check purposes, inch-square bars should be cast in pairs from the first round of the heat, from the second round, from the middle of the heat, and from the last round. These bars are to be used for measuring structure, deflection, and transverse breaking strength, and for chemical analysis. A method of calculating the analysis of the cupola product from the cupola charge is explained. Several items of general molding practice which contribute to successful enameling are discussed, together with the preparation and storage of the castings. E.J.V.

Gases in enamels. VIELHABER. *Emailwaren-Ind.*, **13** [45] 365–66 (1936).—Transparent enamels must be completely melted to insure the escape of all gases from the melt which, if present, will affect transparency. Carbonates and fluorides may escape during firing of the enamel, while nitrates disintegrate at much lower temperatures and can be removed more easily. M.V.C.

Glass-lined steel equipment's benefits to the process industries. ANON. *Enamelist*, **14** [2] 20–23 (1936).—The extensive use of acid-resisting glass-lined equipment by the processing industries has been occasioned by (1) protection of the equipment against acid action and rapid depreciation, (2) protection of the product against contamination and turbidity resulting from dissolved metallic scales, (3) ease of cleaning and sterilization, (4) improved yield by eliminating side reactions that are catalyzed by metal, and (5) elimination of off-flavor and color, particularly of foodstuffs, sometimes acquired during processing stages. Some heavy duty service records of glass-lined equipment are cited. E.J.V.

High requirements of enameled hearths, stoves, and bathtubs. VIELHABER. *Emailwaren-Ind.*, **13** [37] 300–301 (1936).—The appearance of enameled hearths, stoves, and bathtubs is discussed. M.V.C.

How typical welding tests are made. ANON. Preprint of chapter to be included in Lincoln Electric Co. handbook. *Ind. & Welding*, **9** [10] 49–53 (1936).—Details of tests and test-piece preparation are reviewed for tensile, free bend, nick-break, impact, and fatigue tests. W.H.B.

Iron as an impurity in raw materials. VIELHABER. *Emailwaren-Ind.*, **13** [40] 325–26 (1936).—The effect of iron on the coloring of enamels and its elimination by magnetic separation are discussed. A table shows the amount of iron removed by means of magnetic separation. Chemically combined iron present in raw materials which are melted is less important than metallic iron, especially in materials used as mill additions. M.V.C.

Jigs for oxyacetylene welding: I. ANON. Article from a bulletin prepared by the 1935–1936 Oxyacetylene Committee. Reprinted in *Ind. & Welding*, **9** [6] 15–19 (1936).—A thin sheet is more affected by welding heat in regard to distortion due to single direction of expansion and contraction. Three methods of controlling warpage and edge movements, absorbing heat, equalizing the effects of heat, or restraint during welding are discussed for a variety of jigs, clamps, blocks, and separators. W.H.B.

Mechanics of enamel adherence: XIII, A review of the theoretical explanations for formation of metal particles in "cobalt" ground coats and some pertinent experiments. R. M. KING. *Jour. Amer. Ceram. Soc.*, **20** [2] 53–55 (1937); for Part **XII** see *Ceram. Abs.*, **15** [10] 294 (1936).

Neutralizers in porcelain enameling. PAUL E. GERDES. *Enamelist*, **14** [2] 5–8 (1936).—Neutralizer solutions to be used on enameling steel should be composed only of inorganic compounds, the more common types including soda ash in their make-up. They are controlled by determining the per cent sodium oxide available in the neutralizer. The ware to be neutralized is usually allowed to remain in the neutralizer solution for 3 to 10 min. A high temperature is advisable so that the ware will dry rapidly without excessive rusting. The sludge that forms in the neutralizer tanks may cause a scum on the ware, and many plants use a filter press in conjunction with the neutralizer tank to remove the sludge. The effect of the neutralizer carried over on the steel upon the ground coat depends largely upon the neutralizer composition, just as different set-up agents produce different set-up characteristics in the enamel slip. E.J.V.

Nonmetallic inclusions in cast iron; a review of the literature. E. MORGAN. *Bull. Brit. Cast Iron Research Assn.*, **4** [9] 355–61 (1936); Rept. No. 152.—Inclusions of submicroscopic size, colloidal dimensions are suggested as most potent in affecting the properties of Fe. Accidental origin of inclusions is considered as due to contamination of the metal with the refractory of the furnace, ladle, or mold, but of such size as to affect the assembly but not the properties of the metal. Colloid, harmful inclusions originate in slag of the blast furnace and are carried along in the processing; others may have their inception in the release of oxidizing gases during cooling of molten Fe. The trapped gases are regarded as harmful inclusions. A review of the literature on the effect of dissolved O_2 indicates that it gives cast Fe a different structure (finely divided graphite) when absent than when free access to O_2 is the case (coarse graphite flakes). Whether or not the effect is beneficial is inconclusive. Graphite is removed from the category of inclusion since literature shows it to be completely dissolved (subeutectics at least) in molten Fe. The silicate inclusions are most important, being most persistent and capable of submicroscopic subdivision (shine theory). They are thus able to affect the crystallization of the metal, forming coarse graphite. Partial liquefaction of the inclusion can prevent its action as a nucleus and thus remove it from the sphere of influence with respect to the properties of the metal. Bibliography. W.H.B.

Porcelain enameling furnace. ANON. *Enamelist*, **14** [2] 48 (1936).—The gas-fired radiant-tube furnace perfected by the Surface Combustion Corp., Toledo, Ohio, is heated by hairpin-shaped, alloy tube elements placed on the hearth and sidewalls. The gas burns in the tubes to almost perfect combustion, with a nonturbulent flow of flame, never coming in contact with the ware being fired. Contamination of the firing chamber atmosphere by combustion gases is eliminated as the tubes are under negative pressure. Uniform temperature distribution and accurate heat control are easily maintained by arrangement of the tubes. E.J.V.

Preliminary investigation of thermal properties of porcelain enameled steel. ANON. *Enamelist*, **14** [2] 28–30

(1936).—Tests were made, by comparison with Insulite or Celotex, to determine whether porcelain enameled sheet steel had sufficient insulating value to warrant further study. The enameled sheets proved about half as good as 1/2 in. of Insulite as far as protection from radiant heat is concerned. Thickness of the enamel coat seems relatively unimportant. It is roughly 2/3 as effective as 1/2 in. of Insulite in preventing heat leak from the inside of a house to the outside on a cold, still day. E.J.V.

Progress of cast-iron enameling. ANON. *Glashütte*, **66** [46] 779–81 (1936).—The latest American studies on the effect of properties and ways of treatment of cast-iron on enameling are reviewed. M.V.C.

Rational and appropriate drying of enamel. OSCAR KERSTAN. *Glashütte*, **66** [42] 711–12 (1936).—Directions for rapid and correct drying of ground enamel are given. Some contrivances used are described. Illustrated. M.V.C.

Scientific relationship between enamel, glass, and ceramics and its significance for practice: I. A. DIETZEL. *Glashütte*, **66** [26] 448–51 (1936).—D. discusses the relationship between glasses, enamels, and clay bodies, especially refractories. The composition, structure, and properties of these materials are analyzed. M.V.C.

Setting up a pickling-control laboratory and methods for testing solutions. M. J. BOZSIN. *Enamelist*, **14** [3] 9–15 (1936).—The equipment necessary for a small but complete pickling-control laboratory is listed, and an arrangement for building it into a cupboard where space is limited is given. Truly representative samples of pickling baths should be used in control tests. The testing of the cleaner entails determination of (*a*) the concentration (usually expressed in ounces per gallon) and (*b*) the amount of available alkali present. Two determinations, strength and iron content, are necessary for complete testing of the pickling acid. Nickel dip baths must be maintained at correct strength and acidity (p_H). Methods of making all tests are outlined in detail. Illustrated. E.J.V.

Standard designs for service stations. W. B. FISKE. *Enamelist*, **14** [2] 31 (1936).—The Austin Co., Cleveland, Ohio, a large builder of service stations, has developed eight designs for standardized, prefabricated, porcelain enamel service stations which lend themselves to a varied treatment aside from color possibilities. Porcelain panels used are 18-gage steel and are backed by 1/2 in. of insulation board. They are attached to the wall units by a patented method and all spaces are calked. E.J.V.

Technical significance of cobalt and nickel compounds. RUDOLF MÜLLER. *Emailwaren-Ind.*, **13** [40] 327–28 (1936).—The composition and use of various cobalt and nickel compounds used in the ceramic industries are discussed. M.V.C.

Technological relationship between the properties of glass and enamel. ANON. *Glashütte*, **66** [39] 667–70 (1936).—Various properties of glasses and enamels are discussed and compared. Bibliography. M.V.C.

Tools and contrivances used in the enamel industry. C. P. OTTERSBACH. *Glashütte*, **66** [39] 670–73 (1936).—Illustrated. M.V.C.

Welding design. CHARLES H. JENNINGS. *Welding Jour.* [N. Y.], **15** [10] 58–70 (1936).—Fundamental factors governing satisfactory design, methods of calculating weld stresses, and correct working stresses to employ for different types of joints are discussed with sketches, diagrams, tabular data, and engineering formulas. Butt and fillet welds are covered together with theoretical and practical aspects of stress concentrations resulting from discontinuities in form, and fabrication difficulties, welding costs, and distortion problems are considered. Bibliography. W.H.B.

White enamel without opacifier added to the mill. VIELHABER. *Emailwaren-Ind.*, **13** [41] 535–37 (1936).—Various batches are analyzed, and it is shown that with a suitable synthesis of the enamel it is possible to produce well-opacified enamels using only very small quantities of mill opacifiers. M.V.C.

PATENTS

Apparatus for enameling articles. C. S. LARSON AND W. A. KUEBLER (A. O. Smith Corp.). U. S. 2,066,628, Jan. 5, 1937 (Aug. 3, 1935).

Enameled sheet metal and method of making. RUDYARD PORTER AND R. B. SAYLOR (American Sheet and Tin Plate Co.). U. S. 2,065,392, Dec. 22, 1936 (Nov. 27, 1935).

Glass

Anomalous structures of fine crystalline silica. N. A. SHISHAKOV. *Compt. Rend. Acad. Sci. U.R.S.S.*, [N. S.] **1** [1] 19–22 (1936).—Electrographic analysis showed that fused vitreous silica is not an amorphous substance but consists of deformed crystals of cristobalite of the parameters $a = 6.87$ and $c/a = 1.06$. Data of electrograms of silica glass, pumice, and very fine sand are given. A deformation of small crystals of silica is observable in the case of cristobalite and other cases; in the case of very fine sand the elongation along one axis and a transverse contraction along the other one are replaced by a uniform contraction on all sides. P.B. & E.S.

Batch. ANON. *Glashütte*, **66** [35] 595–97 (1936).—A comparison between compositions of glass batches used formerly and at present is given. M.V.C.

Chemical composition and water solubility of glasses: III. SHOICHIRO NAGAI AND KENTARO TAKAHASHI. *Jour. Japan. Ceram. Assn.*, **44** [519] 143–53 (1936).—Experiments were made on the effect of partially replacing silica in a base glass containing 72.62 SiO_2, 0.60 R_2O_3, 12.78 RO, and 14% Na_2O by B_2O_3, TiO_2, or P_2O_5 on its durability. In the determination of the durability, the water-suspended glass grain was heated on a water bath or in live steam of 5 or 10 atmospheres. The order of ability to increase the durability was boric acid, titanic acid, phosphoric acid, and silicic acid after the water bath method and boric acid, titanic acid, silicic acid, and phosphoric acid after the autoclave method. In the latter method, phosphoric acid seems to form the insoluble $Ca_3(PO_4)_2$ as the opacity of the glasses indicates. **IV.** *Ibid.*, [521] 307–16.—In a standard glass containing 72 silica, 13 lime, and 15% soda, a part of the silica, lime, or

soda was replaced by alumina, magnesia, or boric oxide. The glass grains between 64- and 144-mesh/sq. cm. were tested for durability with boiling water and water under a steam pressure of 5 or 10 atmospheres. Results were as follows: (1) the replacement of 3% lime by magnesia was not effective in increasing the durability; (2) replacement of 3% lime by alumina was remarkably effective; (3) replacement of 2% silica by boric oxide was not effective; and (4) sheet and figured glasses on the market are slightly inferior to the experimental glasses, probably on account of their deficiency in alumina, etc. S.K.

Collation of experimental data: Nos. 36–37. A. ALISON. *Glass*, **13** [9] 379; [10] 416 (1936).—A. discusses the use of regression lines in interpreting and explaining certain data. **No. 38.** *Ibid.*, [11] 456.—Abbreviated methods used in calculating correlation coefficients are explained. For Nos. **34–35** see *Ceram. Abs.*, **16** [1] 43 (1937). M.C.S.

Conductivity of a freshly broken glass surface. S. GEDDES. *Jour. Roy. Tech. Coll.* [Glasgow], **3** (Part 4) [1] 551–58 (1936).—The conductivity of a glass edge is shown to be due to condensed matter from the atmosphere. The surface layers of freshly cut glass and split mica are concluded to be of the same thickness and found in the same way from the atmosphere. Curves present data for the conductivity of the glass surface after breaking in air of controlled humidity. W.H.B.

Construction of glass helices for packing fractionating columns. W. W. STEWART. *Ind. Eng. Chem., Anal. Ed.*, **8** [6] 451–52 (1936).—A rapid mechanical method for the construction of glass helices is described and illustrated. F.G.H.

Course in glassmaking. ANON. *Verre & Silicates Ind.*, **7** [31] 369–72 (1936).—The installation of a battery of gas generators is discussed. See *Ceram. Abs.*, **16** [1] 11 (1937). M.V.C.

Devitrification of glass. L. SPRINGER. *Glashütte*, **66** [46] 778–79; [47] 794–96 (1936).—L. discusses the difference between the crystalline and amorphous state and the causes of the appearance of various types of devitrification, such as that of silica (cristobalite) and lime (wollastonite) or that occurring as a white coat or skin (felt). Devitrification is greatly affected by the duration of working and cooling and by temperature. The separate constituents of glass, such as alumina, lime, lead oxide, boric acid, and soda, have a marked effect on devitrification. The working of glass and its cooling are dealt with. Illustrated. M.V.C.

Difficultly breakable glass. R. SCHMIDT. *Osram-Nachr.*, **17** [11] 251–53 (1935); abstracted in *Referat. Silikatliteratur*, **3** [10] 3373 (1936).—The resistance to pressure of hardened glass is discussed, and methods used to obtain it are dealt with. M.V.C.

Disintegration of mullite phase at high temperatures. VLADIMIR ŠKOLA. *Zprávy Československ. Keram. Společnosti*, **11**, 81–86 (1934); abstracted in *Chem. Zentr.*, **ii**, 3144 (1935).—Stones which originate from mullite tank blocks are usually not mullite but a mixture of corundum crystals with small amounts of a finely crystalline mass. S. determined that corundum must have been formed by the disintegration of the mullite phase; this disintegration takes place in glass furnaces between 1400 and 1500° and is accelerated, if not promoted, by alkalis. It seems appropriate to use corundum brick which show a greater durability than mullite stones under these conditions. See also *Ceram. Abs.*, **15** [11] 335 (1936). M.V.C.

Durability of colored glasses. KENJI NAKANISHI. *Jour. Japan. Ceram. Assn.*, **44** [518] 85–90 (1936).—Green glasses colored by minute amounts of chromic oxide or chromium salts as well as brown glasses colored by carbon show better durability than those obtained from respective batches without the colorants. This difference in durability is due neither to volatilization of alkalis nor to other change in the composition of the glasses, because the colored and colorless glasses have the same composition except for the coloring constituents. S.K.

Fundamental reactions in glassmelting: I. KOZO TABATA, TOKIO YOKOYAMA, AND SUSUMU MINEGISHI. *Jour. Japan. Ceram. Assn.*, **44** [522] 375–84 (1936).—Decomposition of the raw materials was investigated with a thermobalance. Batches composed of $(Na_2$ or $K_2)CO_3$, 0.5 (Ca or Mg)CO_3, and $3SiO_2$ dissociate almost completely at temperatures under 900°C. When $^1/_4$ of the $(Na_2$ or $K_2)CO_3$ has been replaced by an equivalent amount of (Na or K)NO_3, the liberation of gases is remarkably accelerated, and the amount of alkali extractable with hot water decreases. In other words, the replacement accelerates the reactions at least at temperatures under 900°C. S.K.

Glass batch and lime. ZSCHACKE. *Glashütte*, **66** [48] 805–807 (1936).—The effect of various constituents, especially lime, and their origin and physical nature on glassmelting and the finished product is discussed in detail. Examples from practice are given. M.V.C.

Glass batch preparation. ANON. *Glass Ind.*, **17** [8] 269 (1936).—As the correct sequence of the reactions that take place in the furnace, the physical and chemical homogeneity of the glass, and the working properties of the glass depend upon the uniformity of the mixture being fed into the doghouse of the furnace, suitable attention must be paid to the mixing and handling of the glass batch to avoid manufacturing difficulties. Methods of mixing and handling the batch are discussed thoroughly. E.J.V.

Glasses colored by carbonaceous matter: I–II. K. FUWA. *Jour. Soc. Chem. Ind. Japan*, **39** [9] 299–300B (1936).—The coloration of glasses by pure graphite, pure carbon, and purified cane sugar is discussed. F. found that the amount of carbon capable of coloring the glass is confined to a short range and that the coloring effect of carbonaceous matter depends more on physical properties than on chemical properties. **III.** *Ibid.*, [10] 373B.—The carbonaceous colorant in the glass is suspended in a fine colloidal state and has no influence on the chemical or physical properties of the glasses studied. The limit of transmission (wave-length curve) of this series of glasses depends only on the iron oxide content and not on the intensity of the apparent color of the glasses. M.V.C.

Glasses containing iron oxide: V. K. FUWA. *Jour. Japan. Ceram. Assn.*, **44** [517] 15–21 (1936).—Experiments were made on glasses of the composition 72% SiO_2, $(12 - x)$% CaO, x% Fe_2O_3, and 16% Na_2O, using ferrous oxalate for the source of the iron oxide, with the following results: (1) The percentage ratio of FeO to FeO + Fe_2O_3 increases from 39% at $x = 2$ to 53% at $x = 10$ as

the total amount of iron increases. (2) The blue color of the glasses with small iron content changes gradually to greenish blue, being green at $x = 6.5$. In general, ferrous oxalate gives deeper and darker colors to the glasses than ferric oxide. (3) Their maximum transmission range is found at a shorter wave-length than that of the glasses colored by ferric oxide. Their percentage transmission is also lower than that of the latter. (4) The percentage transmission of the oxalate glasses at 700 mμ is lower than that of the ferric oxide glasses. (5) The oxalate glasses transmit those short-wave rays to which the ferric oxide glasses are opaque. **VI.** *Ibid.*, [518] 78–85.—The ratio of FeO to FeO + Fe_2O_3, color, and transmission curves have been investigated for the following series of glasses: (*a*) Glasses which contain a fixed amount of iron, *i.e.*, 2% as Fe_2O_3, and whose Na_2O content of 16% has been supplied by varying the proportion of soda ash and Chile niter. No remarkable influence is observable, but the glasses acquire a yellowish tone when the amount of Chile niter is increased, and the first addition of the niter (0.5% as Na_2O) lowers the content of FeO slightly. (*b*) Glasses whose Na_2O or K_2O (1% in 16%) has been supplied by nitrate and 12% CaO has been partially replaced by ferric oxide. An increase of iron oxide intensifies the yellowish green tint for the soda glasses and the greenish yellow tint for the potash glasses. The ratio of FeO to total iron oxide is large when the total iron content is small but has an almost constant value when the content exceeds 0.5% as Fe_2O_3. **VII.** *Ibid.*, [519] 154–58.—The effect of adding 0.1 to 6% of arsenious oxide to the batch of a glass consisting of 72 SiO_2, 10 CaO, 2 Fe_2O_3, and 16% Na_2O on its color has been investigated with the following results: (1) An increasing amount of arsenious oxide intensifies the yellowish tone of the glass slightly. (2) The ratio of FeO to FeO + Fe_2O_3 in the glass remains almost constant for all amounts of As_2O_3, indicating that arsenious oxide is a more powerful oxidizing agent than sodium nitrate. (3) The transmission curves of the specimens of the glasses about 1 mm. thick intersect each other at about 510 mμ. (4) The shortest wave-length of rays transmitted by the glass moves toward a longer one as the amount of the oxide increases; at the same time the transmission at 700 mμ is increased. (5) FeO in a glass must be estimated after arsenious oxide has been driven off as arsenious fluoride. **VIII.** *Ibid.*, [520] 219–30.—A study was made of the effect of adding sugar to the batch of a soda-lime-silica glass containing iron oxide on the degree of oxidation of iron in the glass. Results are as follows: (*a*) When the iron content of the glass remains constant, the ratio of FeO to FeO + Fe_2O_3 decreases with an increase of sugar, the greenish tone being intensified. (*b*) When the amount of sugar is kept constant and the iron content is varied, the ratio increases with an increase of the iron content up to a limit of 1% expressed as Fe_2O_3. The soda glasses change from greenish yellow to blue, while the potash glasses become bluish green. The shortest wave-length of the rays transmitted by the base glass is reduced by a small addition of iron oxide. **IX-a.** *Ibid.*, [521] 297–306.—The paper relates to the effect of metallic powder. Both zinc and magnesium increased the ratio of ferrous oxide to total iron oxides in the produced glasses, whereas they gave yellowish color to the glasses instead of bluish. The latter phenomenon can hardly be explained. **IX-b.** *Ibid.*, [522] 367–75.—F. deals with the effect of the addition of Al powder or $SnCl_2$ to glass batches containing iron oxide on the properties of the glasses obtained. (1) The ratio of FeO to total iron oxides was rapidly raised by increasing the Al powder. The glasses were colored darker, bluish or grayish. The shortest wave-length of transmitted rays was in general reduced with an increase of Al, and at the same time the total transmission was reduced. (2) Stannous chloride proved to be a strong reducing agent for ferric iron in the glasses. The glasses were colorless or colored slightly bluish. The minimum wave-length of the transmitted rays was in general reduced with an increase in the salt, while the wave-length of the ray of the maximum transmission tended to shift toward blue in the spectrum. The transmission curves intersected at 480 to 520 mμ. (3) It is likely that sufficient amounts of zinc and magnesium reduce the ferric oxide to colloidal iron rather than to ferrous oxide and thereby the glasses are colored yellowish. Aluminium makes a glass grayish, while stannous chloride produces the blue color of ferrous oxide. S.K.

Identification of stones in glass. C. L. Thompson. *Glass Ind.*, **17** [8] 265–68 (1936).—T. discusses (*a*) batch stones, (*b*) devitrification stones, and (*c*) refractory stones, on the basis of microphotographs of thin sections which illustrate the findings. E.J.V.

Jubilee of the German-Bohemian glass industry. Otto Kletzl. *Glashütte*, **66** [47] 791–94; [48] 807–809 (1936).—K. discusses the development and artistic achievements of the German-Bohemian glass industry. Illustrated. M.V.C.

Layer-free safety glass. Otto Herfurth. *Diamant*, **58** [32] 373–75 (1936).—Characteristics and methods of manufacture of hardened or chilled glass are dealt with. M.V.C.

Lead germanate and lead silicate glasses. W. Schutz. Translated in *Glass*, **13** [6] 246 (1936); for abstract see *Ceram. Abs.*, **16** [1] 13 (1937). M.C.S.

Mat etching of glass. Kozo Tabata, Tatsuo Yokoyama, and Kenji Nomi. *Jour. Japan. Ceram. Assn.*, **44** [520] 231–38 (1936).—Four plate and chemical glasses were treated with (*a*) a mixture of NH_4F and HF and (*b*) a mixture of KF(or KHF_2) and HF. In the *a* series, the solution must be sufficiently concentrated to produce a beautiful mat surface, and satisfactory results can be obtained at about 30°C and in about 5 min.; a good result is difficult to obtain with the dilute solution even at higher temperatures and with a longer time. With the *b* series, good results can be obtained at a lower concentration than with the *a* series. "Etch crystals" are far smaller than those in the *a* series. The solutions give, under certain conditions, a netlike surface. The etch crystals are produced more easily along scratches and edges. At cords or striae, smaller etch crystals are sometimes produced, and often no crystals are formed. S.K.

Melting and its supervision. Oscar Heiber. *Glashütte*, **66** [41] 699–701 (1936).—A schedule for the melting of pressed glass in a pot furnace with 1000 kg. daily output is discussed. M.V.C.

Metal plating of glass for optical purposes. H. Schulz. *Glashütte*, **66** [40] 685–86 (1936).—The firing method for

coating glasses with gold or platinum products is discussed. The composition of a solution for platinum layers is given. The maintenance of the correct temperature is most important for obtaining good metal coats. The best temperatures for Pt coats are 620 to 650°C for crown glasses and 720°C for plate glass. The glass is heated for 3 or 4 min. The exact composition of the solutions is usually kept secret. Silicon coats can also be applied by means of the thermal reduction method. Another method is to apply gaseous silicon hydride which is precipitated on the glass surface heated to about 500°C. M.V.C.

Microscope in glass technique. HANS SCHULZ. *Glashütte*, **66** [43] 727–29 (1936).—The use of a microscope for investigating the nature and structure of raw materials, the refractories of tanks or pots, fuel, the detection of flaws in the finished products, etc., is discussed. Illustrated. M.V.C.

Mycalex as a construction material for high frequency technique. ANON. *A E G Mitt.*, **8**, 270–71 (1935).—Mycalex is an inorganic compound composed of mica and soft glass. Some mechanical and electrical data are as follows: specific gravity 3.3, dielectric constant 8.0, transverse strength 14,000 lb./sq. in. Metal parts may be imbedded during the hot-pressing operation. The softening temperature is 400°C. Illustrated. L.E.T.

Parting compound in the glass industry. ANON. *Glass*, **13** [9] 395 (1936).—A new parting compound in the form of colloidal graphite suspended in water and oil is being adopted in the glass industry because of its advantages over the old beeswax and mutton tallow. The water suspension of graphite is known as Aquadag and the oil suspension is called Oildag. Through the use of these compounds the working tools are coated with a thin film of colloidal graphite which facilitates working and improves the finish on the glass piece. M.C.S.

Photochemical changes in manganese glasses. JOSEF HOFFMANN. Translated in *Glass*, **13** [10] 419 (1936); for abstract see *Ceram. Abs.*, **16** [1] 14 (1937). M.C.S.

Properties of "multicellular" glasses. BERNARD LONG. *Verre & Silicates Ind.*, **7** [31] 365–68 (1936).—Multicellular glasses are glasses containing a multitude of droplets (cellules) of uniform size, densely packed but not connected; the thickness of the partition which separates them is relatively small in relation to their diameter. These new products are obtained by different methods, notably by creating within the glass during fusion a reversible reaction liberating oxide of carbon at temperatures relatively low (700 to 1000° for ordinary soda-lime glasses), which produces the inflation of numerous gaseous germs (very fine bubbles); these remain in the glass after refining. A rapid study is given of the principal properties of a certain category of multicellular glasses obtained from powders according to a technique not specified. Multicellular glasses fill certain deficiencies of glass silk and glass wool for insulation. M.V.C.

Reactions occurring in the contact layer between refractory material and glass. A. DIETZEL. *Ber. Deut. Keram. Ges.*, **17** [7] 353–64 (1936).—The investigation was carried out to determine the composition of the glassy substance which forms on the surface of refractory material in a tank and which may be the cause of streaky glass. Tests were made with refractory materials of varying compositions and a technical soda-lime glass. The results are plotted in a simplified SiO_2–Al_2O_3–soda-lime glass system. With a temperature of 1400°F, a saturation concentration of 80 to 40% of refractory material in glass occurs at the surface of the refractory in acid to highly basic materials, respectively. The rate at which the glassy substance, formed at the zone of contact of refractory material and glass, becomes mixed with the main mass of glass is of technical importance. From a study of the system in which the results are plotted, it is possible to determine the primary crystals resulting from the decomposition of the refractory by the soda-lime glass. The effect of porosity and of varying mineralogical composition of the refractory material on the results obtained is discussed. E.J.V.

Scratch-resisting power of glass and its measurement. JAMES BAILEY. *Jour. Amer. Ceram. Soc.*, **20** [2] 42–52 (1937).

Silver coating of plate glass. OTTO HERFURTH. *Diamant*, **58** [29] 337–38; [31] 361–62; [33] 389–90 (1936).—The methods of Kaiser and Lumière for silver-plating plate and hollow glass are discussed in detail. M.V.C.

Stony glass. L. SPRINGER. *Sprechsaal*, **69** [38] 550–53; [39] 564–67 (1936).—Stones formed in glass are classified and their testing is studied in detail. A literature index is given. Illustrated. M.V.C.

Supervising thermoelements used in glassmelting. OSCAR KNAPP. *Glashütte*, **66** [38] 652–54 (1936).—Various thermoelements used in glassmelting are briefly discussed, and their supervision is dealt with. M.V.C.

Venetian glass. W. PRENSLER. *Glashütte*, **66** [43] 729–30 (1936).—P. briefly reviews the development of the Venetian glass industry in the Middle Ages and the 16th and 17th Centuries and the results achieved. M.V.C.

Workers' protection in the glass industry. GUTMAN. *Glashütte*, **66** [44] 741–43; [45] 759–62; [46] 775–78 (1936).—Measures taken to protect the health of workmen in various departments in the glass industry are described. Illustrated. M.V.C.

PATENTS

Annealing leer. E. L. WALTERS (Libbey-Owens-Ford Glass Co.). U. S. 2,066,376, Jan. 5, 1937 (May 29, 1933).

Apparatus for making safety glass. E. H. BALZ (Duplate Corp.). U. S. 2,064,514, Dec. 15, 1936 (Aug. 3, 1933).

Apparatus for and method of delivering molten glass. G. E. HOWARD (Hartford-Empire Co.). U. S. 2,067,142, Jan. 5, 1937 (Oct. 18, 1934).

Apparatus for tempering glass. BERNARD LONG (American Securit Co.). U. S. 2,065,862, Dec. 29, 1936 (March 14, 1933).

Art of decorating glass. G. B. WATKINS (Libbey-Owens-Ford Glass Co.). U. S. 2,066,497, Jan. 5, 1937 (June 2, 1933).

Conveying rolls for glass sheets. GLACERIES DE ST. GOBAIN. Ger. 625,484, Jan. 23, 1936 (Dec. 15, 1934); VI/32*a*, Gp. 23_{01}; *Jour. Soc. Glass Tech.*, **20** [80] A285 (1936).—The asbestos rolls for feeding hot glass sheets, *e.g.*, to the leer, are made up of disks thicker at the circumference than at the center.

Device for shaping parisons. K. ZUMPE. Ger. 624,895, Jan. 9, 1936 (Aug. 7, 1934); VI/32*a*, Gp. 15; *Jour. Soc. Glass Tech.*, **20** [80] A284 (1936).—The device comprises two plates of metal capable of being moved toward and away from each other, either individually or simultaneously, the plates being also capable of adjustment as to height independently of each other.

Drawing glass by Pittsburgh process. N. V. HOLLANDSCHE MAATSCHAPPIJ VOOR DE VERVAARDIGING VAN GLAS. Ger. 626,725, Feb. 13, 1936 (Feb. 27, 1933); VI/32*a*, Gp. 23_{III}; *Jour. Soc. Glass Tech.*, **20** [80] A285 (1936).—In the Pittsburgh process of upward drawing of a glass sheet, a burner capable of sidewise adjustment is inserted through one of the side walls to play upon the point where the thickened cooler glass leaves the drawing chamber.

Feeding molten glass to rolls. SCHLESISCHE SPIEGELGLAS MANUFACTUR C. TIELSCH G.M.B.H. Ger. 626,435, Feb. 6, 1936 (Oct. 26, 1932); VI/32*a*, Gp. 19; *Jour. Soc. Glass Tech.*, **20** [80] A285 (1936).—In a plant for the continuous rolling of glass according to Ger. 620,595 (*Ceram. Abs.*, **15** [8] 241 (1936)) provision is made for raising or lowering the system of conveyer rollers feeding the molten mass to the rolls and also for reversing the direction of their rotation.

Floaters for protecting tank walls. B. SCHWEGER. Ger. 625,578, Jan. 23, 1936 (Jan. 3, 1934); VI/32*a*, Gp. 1; *Jour. Soc. Glass Tech.*, **20** [80] A258 (1936).—Protecting floating members of refractory material are made of cylindrical shape and so designed that the movement of the glass and the displacement of the center of gravity by corrosion of the material cause them to rotate.

Forming corrugated glass sheets. GLACERIES DE ST. GOBAIN. Ger. 626,606, Feb. 6, 1936 (June 15, 1934); VI/32*a*, Gp. 27; *Jour. Soc. Glass Tech.*, **20** [80] A285 (1936).—In a process for making corrugated glass sheets from flat ones, by pressing, the sheet is suspended vertically and the forming tools are removed immediately after the molding operation, so that further cooling takes place while the glass is in contact only with the suspending device.

Glass-cutting device. F. S. CAMPBELL. U. S. 2,064,243, Dec. 15, 1936 (Dec. 14, 1935).

Glass feeders. UNITED GLASS BOTTLE MANUFACTURERS, LTD., AND J. TIPPING. Brit. 454,289, Oct. 7, 1936 (July 27, 1935).

Glassmelting tank. K. G. KUTCHKA (Pittsburgh Plate Glass Co.). U. S. 2,064,546, Dec. 15, 1936 (April 6, 1935).

Glass-to-metal seal. HOWARD SCOTT (Westinghouse Electric & Mfg. Co.). U. S. 2,065,404, Dec. 22, 1936 (July 19, 1934). A fused joint or seal between a soft glass having an expansivity of from 7 to 12 $\times$ 10^{-6}/°C and a strain point of about 350° and an iron-nickel alloy incorporating in excess of 1% of an element which enhances the formation, when heated in air, of a readily fusible surface oxide, the alloy having an inflection temperature which is in excess of the strain point of the glass.

Glass resistant to alkali-metal vapors and method of making. R. H. DALTON AND H. P. HOOD (Corning Glass Works). U. S. 2,065,852, Dec. 29, 1936 (Nov. 6, 1934). The method of treating glass to make it resistant to discoloration of hot alkali-metal vapors includes wetting the surface of the glass with a solution of salts consisting of alkali salts and boron compound, which on being heated will leave a residue consisting of alkali oxide and boric oxide, and heating the glass to decompose the salts and fuse the alkali oxide and boric oxide to the glass in a homogeneous layer.

Glassware leer construction. H. B. EASTWOOD (Hartford-Empire Co.). U. S. 20,209, Dec. 22, 1936 (June 12, 1936); reissue of original U. S. 1,997,250, April 9, 1935.

Heat treating glass sheets. F. ECKERT. Ger. 626,941, Feb. 20, 1936 (July 25, 1934); VI/32*a*, Gp. 30; *Jour. Soc. Glass Tech.*, **20** [80] A291 (1936).—A plant for "hardening" the glass is provided in direct connection with the rolling plant, and the necessary annealing to allow grinding and cutting up is carried out afterward in an abbreviated form of leer.

Heat treating glass sheets. HERZOGENRATHER GLASWERKE BICHEROUX & CIE, G.M.B.H. Ger. 628,750, March 26, 1936 (March 13, 1933); VI/32*a*, Gp. 30; *Jour. Soc. Glass Tech.*, **20** [80] A291 (1936).—In a process of "hardening" glass sheets by blowing gaseous or like media onto the previously heated sheets, the velocity of heat transfer from the glass to the cooling medium is regulated by controlling the separation between the sheet and the points of discharge of the medium.

Lensed electric lighting glass tubing. G. H. HUTAFF, JR., AND H. B. NORRIS. U. S. 2,063,930, Dec. 15, 1936 (June 28, 1935). A gaseous conduction lamp has a tubing with a lensed area therein, the lensed area being formed with corrugations presenting prisms concentrically disposed to the logitudinal center of the tubing.

Lens grinding machine. L. G. SIMPSON (Bausch & Lomb Optical Co.). U. S. 2,065,103, Dec. 22, 1936 (Nov. 1, 1935).

Lens and method of making. F. D. KINNEY (American Optical Co.). U. S. 2,067,194, Jan. 12, 1937 (June 6, 1935).

Machine for manufacturing glass bottles, etc. W. E. EVANS (F. O'Neill). Brit. 457,030, Dec. 2, 1936 (Feb. 15, 1935).

Method and apparatus for cooling hollow glass articles. H. A. WADMAN (Hartford-Empire Co.). U. S. 2,066,283, Dec. 29, 1936 (Nov. 20, 1935).

Method and apparatus for shaping glassware. KIMBLE GLASS CO. Brit. 454,068, Oct. 7, 1936 (Feb. 21, 1935).

Method and means for producing partitioned glass containers. N. R. BECK (Carr-Lowrey Glass Co.). U. S. 2,065,504, Dec. 29, 1936 (May 1, 1935).

Multifocal ophthalmic lens and blank and method of making. J. H. HAMMON. U. S. 2,065,132, Dec. 22, 1936 (Jan. 18, 1933).

Ophthalmic lens and method of making. C. L. BAUSCH (Bausch & Lomb Optical Co.). U. S. 2,065,502, Dec. 29, 1936 (Dec. 16, 1935).

Optical glass composition. M. R. SCOTT (Bausch & Lomb Optical Co.). U. S. 2,064,361, Dec. 15, 1936 (March 7, 1932; March 28, 1935). A colored optical glass has a refractive index between 1.50 and 1.55 and a dispersion, as expressed by ν, between 51.0 and 58.5 and comprises compounds of lead, manganese, and cerium.

Ornamented glass and method of producing. SEBET

SILVERMAN. U. S. 2,065,406, Dec. 22, 1936 (May 17, 1935).

Production of "bubbly" glass. SOC. ANON. DE ST. GOBAIN. Ger. 626,607, Feb. 6, 1936 (March 10, 1934); VI/32*b*, Gp. 1; *Jour. Soc. Glass Tech.*, **20** [80] A270 (1936).—Glass of suitable composition is cast in a mold preheated to about 400° and then put under reduced pressure after reaching the correct viscosity. This causes it to swell and fill the mold, from which it is next removed and annealed.

Production of glass threads. N. V. MAATSCHAPPIJ TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Ger. 627,619, March 5, 1936 (Dec. 18, 1933); VI/32*a*, Gp. 25; *Jour. Soc. Glass Tech.*, **20** [80] A273 (1936). Addition to 539,738 (*Ceram. Abs.*, **12** [4] 152 (1933)).—A stream of air, gas, or vapor is used on the rotating disk upon which the molten glass impinges.

Production of glass wool. OWENS-ILLINOIS GLASS CO. Ger. 626,436, Feb. 6, 1936 (Feb. 26, 1934); VI/32*a*, Gp. 25; *Jour. Soc. Glass Tech.*, **20** [80] A273 (1936).—In a process for making glass wool in which a glass stream flowing from a container is dispersed by a blast of some medium, the directions of flow of the two substances are so disposed that the breaking-up blast acts in the direction of flow of the glass.

Production of opaque glasses. E. KNUDSEN. Ger. 627,730, March 5, 1936 (Jan. 18, 1933); VI/32*b*, Gp. 2; *Jour. Soc. Glass Tech.*, **20** [80] A270 (1936).—In an opaque glass obtained by the dispersion of one phase within another, the compositions of the two phases are so chosen that the dispersion curves intersect in that part of the spectrum corresponding to the light it is desired to pass through undispersed, all other light being dispersed at the interfaces of the two phases.

Reflecting glass. C. A. JAMES (A. M. Ducey). U. S. 2,067,701, Jan. 12, 1937 (June 27, 1933; renewed March 25, 1936). A reflector of pressed glass has its front and rear faces convexly cylindrical, the front face being smooth and the rear face comprising a plurality of curved double reflectors, the front face and the double reflectors being curved about a common center line and arranged in collimating relation, whereby light entering the front face is converged upon the double reflectors and returned therefrom back through the face toward its source.

Structural Clay Products

Brick roads in Holland. P. W. SCHANN AND J. W. CLEUX. *Claycraft*, **10** [1] 21 (1936).—Brick-road construction in Holland was begun about 1805, and at present nearly 800 miles of the 1400 miles of main highways are brick surfaced. Specifications of the brick used, preparation of the road base, and methods used in laying the brick are given. M.C.S.

Contribution to testing the resistance of ceramic materials to changes in temperature. R. BARTA. *Bull. Amer. Ceram. Soc.*, **16** [1] 5–7 (1937).

Modular masonry. FREDERICK HEATH, JR. *Bull. Amer. Ceram. Soc.*, **16** [1] 17–20 (1937).

Netlike cracks in brick. P. THOR. *Tonind.-Ztg.*, **60** [87] 1077–78 (1936).—Netlike cracks appearing occasionally on the surface of brick fired in circular kilns are due to improper drying of the brick. M.V.C.

Tested brick for road paving. A. E. BLIZZARD. *Brit. Clayworker*, **45** [536] 278–81 (1936).—B. gives a summary of data on brick as road-paving material, compares prime and maintenance costs of brick and other road pavings, and lists seven advantages of brick roads. R.A.H.

Thermal behavior of brick. O. STADLER. *Rev. Matériaux Construction Trav. Publics*, No. 325, pp. 145–48B; No. 326, pp. 165–69B (1936).—This is a translation of an article which appeared in Physik des Backsteins (*Ceram. Abs.*, **15** [3] 92 (1936)). S. gives the fundamental principles which control the qualifications of building materials with regard to their thermal insulating power; practical examples and the behavior of the brick in comparison with other building materials are discussed. Conclusions are as follows: (1) As a result of drainage the thermal insulation of the brick improves with time, although with other materials an absorption of humidity which decreases thermal insulation is often produced because of the formation of cracks. (2) The brick industry has made and still makes an effort to adapt the exterior form and the arrangement of the holes of the brick in order to increase insulating power. (3) With regard to insulating power, brick can be compared to advantage with other building materials. (4) Brick masonry must be perfectly built so that no fissures can form in the joints and allow air to enter. M.V.C.

PATENTS

Building construction. ANDREW HOHNER. U. S. 2,066,268, Dec. 29, 1936 (June 12, 1936).

Weatherproofing of walls. H. S. SMITH. U. S. 2,065,623, Dec. 29, 1936 (Jan. 25, 1935).

Refractories

Brick of artificial agglomerated mullite. PIERRE BERGERON. *Verre & Silicates Ind.*, **7** [32] 378–82 (1936).—The brick were made by grinding waste brick of fused refractory, then agglomerating according to ordinary ceramic processes with a special extra fat clay, and firing at 1450°. The alumina content of the product obtained is about 66%. Refractory silico-aluminous brick with a high alumina content have the special property of not being dissolved by the action of the dust but of forming with it a viscous glaze on the surface which protects the brick from further attack. The results of laboratory tests and the use of such brick in industry show its superior resistance. M.V.C.

Effect of type of surface on radiation loss from furnaces. B. J. CROSS. *Combustion*, **7** [7] 33–36 (1936).—A brief discussion of the absorption of heat by furnace walls, its transfer through the wall by conduction, and its dissipation by radiation and convection is given. Basic formulas and

curves for determining the heat loss are included, and the effect of different emissivity factors for various surfaces is commented upon. H.E.S.

Electrographite, its manufacture, properties, and application. R. Strauss. *Chem.-Ztg.*, **60** [65] 661–63 (1936).—S. discusses (1) methods of manufacture, (2) properties of electrographite, and (3) its use in the iron and steel industries. A series of patents is discussed. M.V.C.

Firing refractory brick. R. Klesper. *Feuerungstechnik*, **24** [10] 174–79 (1936).—Grog brick are affected by firing with regard to their shape, volume, specific gravity and porosity, resistance to chemical attack, mechanical strength, and refractoriness under load. These properties are dealt with, and the firing of grog brick in gas-heated annular kilns is discussed in detail. *Ibid.*, [11] 196–99.—The firing of refractory brick in various types of gas-fired chamber furnaces is discussed in detail. Illustrated. M.V.C.

Fused magnesia in the nonferrous metal industry. W. L. Patrick. *Metal Ind.* [London], **48** [8] 231–32 (1936).—The crystalline magnesia obtained by fusing a magnesite of a high degree of purity is extremely refractory, having a fusion point approaching 2800°C, and highly inert to the chemical action of metals, basic slags, and the usual fluxes at high temperatures. In spite of its high thermal conductivity, it is a poor conductor of electricity. Impurities, particularly silica and ferric oxide, influence most of these properties adversely. The crystalline form is stable at all temperatures below the fusion point. No sudden changes in physical properties occur during heating or cooling; consequently shapes prepared from it possess durability. See *Ceram. Abs.*, **15** [10] 302 (1936). H.E.S.

Gradings for high density. F. O. Anderegg. *Bull. Amer. Ceram. Soc.*, **16** [1] 11–13 (1937).

Insulating brick for cement rotary kilns. T. Yoshii. *Jour. Soc. Chem. Ind. Japan*, **39** [6] 204–206B (1936).—The advantages and disadvantages of insulating brick for cement rotary kilns are discussed. M.V.C.

Introduction to the symposium on "Production of dense aggregates." Nelson W. Taylor. *Bull. Amer. Ceram. Soc.*, **16** [1] 7–8 (1937).

Manufacture of tank blocks. A. Möser. *Tonind.-Ztg.*, **60** [88] 1085–86; [89] 1100–1101; [91] 1120–22 (1936).—M. discusses in detail the following factors in the production of grog brick: (1) raw materials, (2) working, (3) composition, (4) mixing and working, (5) shaping, and (6) charging and firing. M.V.C.

Melting of platinum. C. M. Hoke. *Metal Ind.* [N. Y.], **36** [12] 468 (1936).—A description of the lime crucible used for this work is given. Comparison is made with other types of refractories. H.K.R.

Methods for testing silica (Dinas) brick. S. S. Kazakevich. *Zavodskaya Lab.*, **3** [2] 135–40 (1934).—Based on the experience of the refractory plant of a large machine-building works, a program of quality control of silica brick under service conditions has been worked out, including (1) outward inspection of the brick, grading, and sampling; (2) preliminary laboratory investigation; (3) investigation of an experimental lining of an open-hearth furnace crown; (4) investigation of the heat flow in the experimental lining; (5) investigation of the behavior of the crown; (6) inspection of the crown before repairs; and (7) investigation of fired brick. Investigations 2 to 7 are described in detail. P.B. & E.S.

Monolithic furnace construction. J. Duguid. Read before Junior Inst. of Engineers. Abstracted in *Glass*, **13** [11] 475 (1936).—D. discusses firebrick materials. The specifications of an ideal refractory material are given, and the following mix is given as one which tends to approach the ideal: 70% graded calcined grog, 20% plastic clay, and 10% moisture. M.C.S.

Physical properties of Corhart brick. Kitsuzo Fuwa and Shuyu Ito. *Jour. Japan. Ceram. Assn.*, **44** [519] 171–75 (1936).—Domestic and foreign Corhart brick as well as a similar electrocast brick have been examined for certain properties with the following results: (1) Specific gravity is 3.2. Average apparent specific gravity is about 3.0. Apparent specific gravity and porosity vary from the surface to the interior, the latter ranging between 1 and 8%. (2) The development, size, orientation, etc., of mullite and corundum, amount of pores, cavity, and glass, etc., vary with the specimens and their portions. (3) The weight loss of pieces in the mixture of HF and H_2SO_4 in the ratio of 2:1 is strongly affected by the apparent specific gravity; it is almost alike for all ground samples. (4) Linear thermal expansion for 15° to 400°C is 1.37×10^{-6}, for 400 to 700°, 3.67×10^{-6}, and for 700 to 1350°, 5.58×10^{-6}; no abnormality is shown. (5) It is said that Corhart sustains about 15% volume shrinkage in its casting; therefore it may have a porosity amounting to about 13%. Photographs by an X-ray method (80 kv., 3 ma., 2 min.) show large cavities and internal cracks. S.K.

Practical applications of X-rays for the examination of materials. W. G. Burgers. *Phillips Tech. Rev.*, **1** [6] 188 (1936).—X-ray diffraction patterns of zirconium carbide and thorium oxide are given. The pictures are used to identify material to determine its crystal structure. See *Ceram. Abs.*, **16** [1] 40 (1937). H.K.R.

Preparation of laboratory refractory crucibles. P. S. Roller, D. Rittenberg, and A. Gabriel. *Ind. Eng. Chem., Anal. Ed.*, **8** [6] 486 (1936).—A crucible mold and a procedure for its use in the construction of small laboratory crucibles for service above 1500°C are described in detail. Illustrated. F.G.H.

Production of alumina from alunites. S. V. Labutin. *Legkie Metally*, **3** [9] 46–48 (1934); abstracted in *Chem. Zentr.*, **ii**, 1075 (1936).—To obtain a greater yield when manufacturing aluminum from alunites it is necessary to dissolve with NaOH in two stages, in which the alkali sulfates go into solution first in the presence of $Al(OH)_3$ and only then is $Al(OH)_3$ changed into aluminate by NaOH. NaOH set free during hydrolysis of aluminates reacts with undissolved alunite and forms Al(OH), again. M.V.C.

Recent developments in refractories. C. E. Moore. *Metal Ind.* [London], **48** [1] 8–13 (1936); see *Ceram. Abs.*, **15** [5] 154 (1936). H.E.S.

Refractories for furnaces using waste products for firing. K. Lentzen. *Feuerungstechnik*, **24** [10] 181–82 (1936).—The leather, furniture, and paper industries, etc., use waste products of their industries for firing, and the refractories

used show a characteristic shell-like spalling, especially in the vicinity of the joints. This destruction is chiefly accounted for by the fuel used and incorrect firing. The refractories should answer the following requirements: (1) high refractoriness, cone 33 or 34, (2) dense structure, and (3) high resistivity to temperature variations. Mortar for the joints should be of the same composition as the refractories, if possible, and have similar properties, especially good adherence. M.V.C.

Refractory cements in industry. W. O. LAKE. *Sands, Clays & Minerals*, **3** [1] 51–52 (1936).—The uses of cement in metallurgical processes are considered under three groups: (1) Highest temperatures, 1600 to 1700°C. Magnesite brick or tamped dolomite is used for the bottoms of such furnaces, and finely ground silica cement rich in SiO_2, bonded with milk of lime, is used for joints. Alumina refractories with 70 to 80% Al_2O_3 are employed in oil-fired basic furnaces, joined with high alumina cement. (2) Temperatures from 1400 to 1600°C. In blast furnaces, foundry cupolas, etc., silico-alumina brick of 30 to 35% Al_2O_3 are used, preferably with a cement of the same type. (3) Furnaces, stoves, fireplaces, for 800 to 1400°C. No special refractories and cements need be applied but the material selected should be appropriate for the purpose. M.H.

Refractory lining of cement kilns. D. STEINER. *Zement*, **25** [37] 619–24 (1936).—S. discusses the principal problems of the lining required in the sintering zone. An outline of recent development is given. The temperature-resistant magnesia stones and their physical and chemical properties are discussed. Their durability is a multiple of that of former material, and they are decidedly superior from the caloritechnical viewpoint. F.E.V.

Silica refractories. ANON. *Trade & Eng. Supp.*, **40** [874] xxv (1936).—Rationalization has been found essential in the chief silica brickworks in South Wales. Two kinds of brick are made: (1) a high-grade silica brick for use in the steel industry, with a refractoriness of 1710°C under a load of 50 lb./sq. in. and (2) a silica brick for use in the glass, gas, and copper industries with a refractoriness under load of 1650°C. The demand for best quality brick is increasing; "cheap brick" are found to be more expensive in use. A.B.S.

Silica stone. ANON. *Trade & Eng. Supp.*, **40** [874] xliii (1936).—Over 840,000 tons of silica stone (including ganister and silica sand) were quarried in North Wales in 1935 for use as a refractory material. This output was greater than that from the whole of Scotland and was only exceeded in three English counties, Bedford, York, and Durham. The best-known Welsh silica rock is the Bwlchgwyn quartzite, brick from which are used in steel furnaces, glassworks, coke ovens, and gas retorts in England and Scotland. A.B.S.

Testing refractory materials on the basis of their mullite content. MARCEL LÉPINGLE. *Congr. Chim. Ind., 15th Congress, Brussels*, **1**, 119–25 (1935); abstracted in *Chem. Zentr.*, **ii**, 1596 (1936).—A description is given of a series of tests with refractories having a variable alumina content. The effect of this content on specific gravity is discussed, and the relationship between the kind of bond used, porosity, and resistance to pressure is dealt with. See "Refractory—" *Ceram. Abs.*, **16** [2] 64 (1937). M.V.C.

Unfired agalmatolite brick. SEIJI KONDO AND AITARO MIYAGAWA. *Jour. Japan. Ceram. Assn.*, **44** [518] 97–103 (1936).—Unfired fire brick, which have a compressive strength of 100 kg./sq. cm. or more, are almost as refractory as their chief raw materials and resistant to thermal shock. They do not shrink materially on heating and have been obtained by adding bonding materials such as glue, casein, water glass, etc., to a mixture of 80 parts of agalmatolite and 20 parts of agalmatolite clay or a mixture of 93 parts of agalmatolite and 7 parts of Kibushi-clay (ball clay). S.K.

Value of proper furnace equipment to power plant economy. M. K. DREWRY. *Combustion*, **7** [12] 39–42 (1936).—Contending that the furnace is the starting point in a search for economy, D. discusses the numerous variables involved such as excess air, effect of furnace temperature on efficiency, superheat behavior as affected by furnace conditions, radiant heat absorption, and a comparison of the dry bottom and slagging types. Furnace temperatures higher than 2000°F are more likely to decrease than to increase combustion efficiency. H.E.S.

PATENTS

Arch and arch block. G. P. REINTJES. U. S. 2,067,414, Jan. 12, 1937 (March 18, 1935).

Method of manufacturing articles from refractory or sinterable materials. W. C. HERAEUS GES. Brit. 454,071, Oct. 7, 1936 (Feb. 18, 1935).

Process for making silica stone material. HERMANN SALMANG AND BENNO WENTZ. U. S. 2,066,366, Jan. 5, 1937 (July 7, 1932). The method of making silica stone material consists in firing a mixture of raw silica material, lime, and a frit containing an alkali oxide and a metallic oxide.

Refractory bodies. G. E. SEIL (E. J. Lavino & Co.). U. S. 2,066,543, Jan. 5, 1937 (April 10, 1936). A refractory starting material comprises chromite, spinel, and mullite.

Tridymite stone. HERMANN SALMANG AND BENNO WENTZ. U. S. 2,066,365, Jan. 5, 1937 (Nov. 20, 1930). A method of manufacturing tridymite stone consists in firing for about 20 hr. a silica mass, of which part is finely ground, mixed with sulfite of lye and the approximate proportions of 2% chalk, 1.5% natron, and 1.5% iron oxide with pyrometer cone 15 to 16.

Terra Cotta

Floor-tile manufacture. JOSEPH GREIVE. *Tonind.-Ztg.*, **60** [81] 999–1001; [82] 1016–18; [83] 1029–1030; [84] 1044; [85] 1050–51 (1936).—A detailed description is given of the separate stages of production of floor tile with special regard to the preparation and working of the raw mix and brick. Illustrated. M.V.C.

Roof-tile bodies. W. KAUFMANN. *Ziegelwelt*, **66** [23] 253–55; [25] 271–73; [26] 282–84 (1935); abstracted in

Referat. Silikatliteratur, **3** [10] 3381 (1936).—The working of various kinds of clay used for roof tile is discussed in detail. M.V.C.

Surface treatment of roof tile. F. LINDENER. *Tonind.-Ztg.*, **60** [94] 1155–56 (1936).—Methods of treating roof tile surfaces are (1) glazing with a glaze composed of clay, silica, and alkalis or boric acid, (2) engobing, (3) salt coating (salt glaze of the same type as is used for stoneware), and (4) engobing with subsequent polishing. These methods are briefly discussed and some patents are described. M.V.C.

BOOKS

Manufacture of Roofing Tile. V. PINKL. Wilhelm Knapp, Halle, Germany. 89 pp. Reviewed in *Brit. Clayworker*, **45** [536] 285 (1936).—P. gives a general picture of the manufacture of roofing tile. The fundamental conditions are shown for the erection of a roofing tile works or for the incorporation of such works in an existing brick factory, as well as the details of manufacture. R.A.H.

Whiteware

Dolomitic porcelain. JIRO SAWAMURA. *Jour. Japan. Ceram. Assn.*, **44** [517] 35–37 (1936).—The cone 10 porcelain body of the Potteries Institute in Kioto consists of 60 parts of Amakusa stone (a decomposed liparite), 25 parts of Gairome clay (a plastic kaolin), and 15 parts of Kawachi feldspar. On adding 3 parts of Tsukumi dolomite, it matures at cone 8. A further addition is apt to cause warping. White Japanese bodies rarely contain white color beyond 75% as measured by a Pulfrich photometer, although superior bodies show about 83%. Bone china often shows 85%. Cone 8 bodies which are markedly translucent and contain 76% or more of white color have been obtained by using 2 to 3% of the dolomite and other raw material poor in iron and titanium. S. also gives two bodies which have 65 to 70% whiteness and are fit for porcelain tableware and vitreous china. They mature at cone 7 to 8. Batches for a cone 7 to 8 fritted glaze and a cone 1*a* glaze are given. S.K.

Effect of various zirconium and titanium compounds on a glaze. C. J. KINZIE AND C. H. COMMONS, JR. *Bull. Amer. Ceram. Soc.*, **16** [1] 1–4 (1937).

Effect of ZrO_2 and TiO_2 upon the resistance to crazing of a typical glaze for semivitreous dinnerware. J. W. HEPPLEWHITE. *Jour. Amer. Ceram. Soc.*, **20** [2] 60–61 (1937).

Electrical characteristics of suspension-insulator units. C. L. DAWES AND REUBEN REITER. *Elec. Eng.*, **56** [1] 59–66 (1937).—The effects of humidity, corona, and mechanical stress on the electrical characteristics of porcelain and glass suspension-insulator units are shown. Moisture, alone and combined with corona, is found to produce surface deposits which cause hysteresis effect in the power, power factor, and capacitive characteristics, and mechanical stress is found to reduce the power factor and capacitance. The effect of stress is reduced where soft metal is used in place of cement in assembling the unit. G.M.P.

Heat-stable micanite with a water-glass base. E. K. LASHEV AND A. I. SHIMANKO. *Mineral. Syr'e*, **9** [6] 28–35 (1934); abstracted in *Chem. Zentr.*, **ii**, 3423 (1935).—Heat-stable micanite articles for a.-c. apparatus for temperatures up to 650° can be produced from small mica particles with Na-water glass as a bond. The best results are obtained with hard phlogopite, while muscovite, which is less stable on heating, is less suitable for this purpose. The water-glass content may be lowered by 4 or 5% without decreasing the mechanical strength of the product. Pressing is done with heat with a specific pressure of 40 kg. M.V.C.

High mechanical strength of steatite insulators. K. STEINBRECHER. *Stemag-Nachr.*, No. 14 (1936); abstracted in *Referat. Silikatliteratur*, **3** [10] 3359 (1936).—The mechanical strength of steatite insulators and experiments of shooting with various types of missiles to test their strength are discussed. M.V.C.

Impact strength of tableware, especially of plates. KANEKOTO FUJII. *Jour. Japan. Ceram. Assn.*, **44** [517] 1–14 (1936).—Breakage of tableware in everyday use is caused by impact in almost all cases. The impact strength of the ware depends on the thickness of its brim and bottom and its shape. F. tested plates made in Japan by means of a pendulum impact machine. The result indicates that the angle which the bottom makes with the brim influences the strength, but further experiments are required for the exact relationship. S.K.

Talc in the porcelain mix. ANON. *Corriere Ceram.*, **17** [10] 303 (1936).—The results of recent experiments in the use of talc in porcelain mixes are as follows: (1) the per cent of talc in porcelain mixes has little effect on the quantity of water which the mix can absorb after being fired; (2) the total linear contraction when the firing is done at 1260°C diminishes at the same rate at which the proportion of talc increases, *i.e.*, 8% with 2.50% talc, 0.7% with 43% talc; (3) the thermic dilatation increases generally when the addition of talc surpasses 30%. M.V.C.

Working steatite and Frequenta products. ANON. *Stemag-Nachr.*, No. 14 (1936); abstracted in *Referat. Silikatliteratur*, **3** [10] 3323 (1936). M.V.C.

Yellow and gray coloring of porcelain. ANON. *Corriere Ceram.*, **17** [10] 303 (1936).—The yellow coloring of porcelain is caused by FeO in combination with Ti_2O_3. In a reducing atmosphere $FeO{\cdot}Ti_2O_3$ gives a gray coloring; 2 or 3% borate nullifies this action. M.V.C.

BULLETIN

Mechanical-electrical stress studies of porcelain insulator bodies. C. W. PARMELEE AND J. O. KRAEHENBUEHL. *Univ. Illinois Eng. Expt. Sta. Bull.*, No. 273, 70 pp. (1935).—The relation and correlation between electrical and mechanical properties of high-tension porcelain insulators are studied. Test methods and equipment are described in full and the results are discussed. In general, superior quality in one property will probably be accompanied by superiority in the others. A marked relationship exists between mechanical and electrical strength, the correlation between compressive and dielectric strength being 0.71, while that between tensile and dielectric strength is 0.88. The breakdown voltage

changes when the body is under a tension load, but no specific law could be established. To obtain reliable results, the size of the specimen used in determining the dielectric strength must be large, and 20 to 30 samples should be used to arrive at a reliable average. A definite law can be established for the behavior under simultaneous electrical and compressive stress, a maximum of breakdown voltage being reached at about 15% of the ultimate load strength when a reversal takes place and the breakdown voltage falls off. Microscopic and macroscopic studies of the puncture under electric load were also made. M.H.

PATENTS

Defecator. W. C. GROENIGER (John B. Pierce Foundation). U. S. 2,066,881, Jan. 5, 1937 (June 30, 1934). U. S. 2,066,882, Jan. 5, 1937 (Oct. 19, 1934).

Defecator with integral evacuator. W. C. GROENIGER (John B. Pierce Foundation). U. S. 2,066,883, Jan. 5, 1937 (June 7, 1935).

Equipment and Apparatus

Apparatus for the measurement of thermal expansion. J. W. BAMPFLYDE. *Bull. Brit. Cast Iron Research Assn.*, **4** [10] 389–90 (1936); Rept. No. 154.—The apparatus is described and illustrated. The curve indicates that excellent results are obtained in picking out critical temperatures for heating and cooling. W.H.B.

Automatic furnace temperature regulator. METROPOLITAN-VICKERS ELECTRICAL CO., LTD. *Jour. Sci. Instruments*, **13** [11] 374–76 (1936).—The temperature regulator described is extremely sensitive and reliable. It will hold furnace temperatures in the region around 600°C to within ±0.1°C for periods of several hours. Vacuum tubes are used in the hookup. Over-all dimensions are 20 x 10 x 15 in. Illustrated. J.L.G.

Ceramic-metallic joints for high vacuum. H. HANDREK. *Z. Tech. Physik*, **17** [11] 456–59 (1936).—H. reports on new methods of sealing together ceramic materials and metals for high-vacuum work. The metal is preshrunk and forced to show the same coefficient of expansion as the ceramic material. A glassy substance is used as a solder. Metal tubes may be sealed to ceramic tubes and plates, and leads for very high current may be conducted into a vacuum-tight container. Illustrated. W.M.C.

De-airing in the auger machine without vacuum pump. W. D. RICHARDSON. *Bull. Amer. Ceram. Soc.*, **16** [1] 14–16 (1937).

De-airing sewer pipe. J. E. RANKIN. *Jour. Amer. Ceram. Soc.*, **20** [2] 64–65 (1937).

Development of a successful periodic humidity drier for grogged ware. ALBERT C. GERBER. *Jour. Amer. Ceram. Soc.*, **20** [2] 56–59 (1937).

Developments in temperature-control equipment. ANON. *Ind. Heating*, **3** [10] 645–66; [11] 755–62, 792; [12] 821–24, 842 (1936).—Temperature-measuring and control devices, manually and automatically operated, and combustion safeguards are described in detail. Illustrated. M.H.

Draft or overfire pressure-control system. BROWN INSTRUMENT CO. *Instruments*, **9** [12] 329 (1936).—An air-operated automatic control system for maintaining either draft or furnace pressure at a predetermined value consists of an instrument and a special damper-operating pneumatic cylinder. The instrument is essentially an inverted-bell type of pressure or draft-responsive element equipped with an "Air-o-line" control system, possessing automatic-reset and throttling range adjustments so that predetermined values may be maintained under widely varying load. Illustrated. R.W.R.

Drying ceramic molded ware. FRIEDRICH LIPINSKI. *Tonind.-Ztg.*, **60** [89] 1096–98 (1936).—The theory of the process of drying ceramic ware is discussed. M.V.C.

Dust counter. BAUSCH & LOMB OPTICAL CO. *Instruments*, **9** [12] 327 (1936).—This instrument permits dust counts to be made easily without previous experience and combines in one unit the necessary air-sampling device, dark-field microscope (200× magnification), and viewing and counting mechanism. It is mounted on a circular base, provided with illuminating apparatus, and suitably cased for handling. In use, air is drawn through a moistening chamber by means of an accurately calibrated hand pump, and the dust particles are caused to impinge on a circular glass plate within the instrument. Twelve samples may be collected on one slide. The samples may be viewed at once or preserved for future reference. The apparatus is so calibrated that when the number of dust particles in the square field is multiplied by 100,000, the result is the total dust count per cubic foot. R.W.R.

Efficiency of a reaction turbine stage from static model tests with air. W. R. NEW. *Combustion*, **7** [7] 27–32 (1936).—In model testing with air, precise measurements are possible, the testing equipment can be made relatively simple, and the observers may work directly with exposed jets without personal danger. However, the fact that all conditions of mechanical similarity can not always be satisfied makes necessary the application of knowledge based on experience. As to the methods of determining velocity coefficients, *viz.*, the reaction test and the impact traverse test, N. explains the limitations of the former and shows how the latter is better adapted for accurate determinations over the entire range of velocity ratio. H.E.S.

Improved turner's lathe. ANON. *Pottery & Glass Record*, **18** [11] 284 (1936).—A new lathe is described which has several new features, including unusual rigidity, complete absence of vibration, complete exclusion of dirt, and lower running costs. By pressing a knee-lever, the speed can be reduced and then gradually reversed, thus making it suitable for turning ware of different sizes. It has ball bearings throughout, and the motor is a component part of the frame. A.B.S.

Improvements on existing machinery: I, Grinding plant. W. H. BATES. *Brit. Clayworker*, **45** [536] 264–65 (1936).—Improvements on a 9-ft. diameter perforated grinding pan purchased over 30 years ago are discussed. In this case, the saving in power with the use of ball bearings in the pan was 16%. R.A.H.

Interferometer as an aid in ceramic research. HANS LEHMANN AND T. M. SCHULZE. *Zeiss Nachr.*, **10**, 6–13

(1936).—The Zeiss apparatus serves for the determination of the coefficient of expansion of ceramic bodies and glazes. It consists of the interferometer, optical arrangements, and the electrical vacuum furnace. Methods for making expansion tests are described in detail. The furnace may be heated from room temperature to 2200 °F. The samples (fired silicates and glazes) are ground to cylinders of 0.8-in. diameter and various lengths and supplied with a high polish. A Zeiss optimeter measures the specimens to an accuracy of $\pm 0.3\,\mu$ (0.00001 in.). Calculation of the thickness of the air layer is carried out according to the computing process by Pulfrich, which is again simplified by the development of the Zeiss light-wave rule after Koesters. Illustrated. L.E.T.

Measurement of moisture in drying installations of brickworks. KARL SPRINGLER. *Tonind.-Ztg.*, **60** [69] 848–51 (1936).—A new instrument, the "hair hygrometer," for measuring moisture in driers and its operation are described. M.V.C.

Microbalance. Collective report. G. GORBACH. *Mikrochemie*, **20** [4] 254–335 (1935).—The history of microchemistry is closely connected with the construction of balances of highest sensitiveness. The development of such balances and their different types, auxiliary equipment, and optical accessories are described. Illustrated. L.E.T.

Notched-bar impact tests of longitudinal and transverse specimens. Influence of annealing and overstrain. J. MUIR. *Jour. Roy. Tech. Coll.* [Glasgow], **3** (Part 4) [1] 531–41 (1936).—Longitudinal specimens snapped at V notches, breaking across the fibers; transverse samples were torn apart and opened at V notches without snapping. Curves show the Hounsfield tensometer test values for the material (0.30 C mild steel) in normalized, annealed, and overstrained condition. W.H.B.

Parallel operation of fans. H. F. HAGAN. *Combustion*, **7** [10] 24–26 (1936).—In discussing the factors essential to successful parallel operation of fans, H. uses graphical analyses based on system curves of constant resistance. The method of determining fan characteristics is reviewed, and the characteristics of different types of fans are touched upon; curves are included covering parallel operation of fans running at different speeds. H.E.S.

Photoelectric photometers and colorimeters. KASSON S. GIBSON. *Instruments*, **9** [12] 335–38 (1936).—G. discusses photoelectric devices for quantitative chemical analyses and for colorimetric use, the filters required, and the nature of errors involved in use of filters as well as reliability of data, reference standards of reflectance, and other conditions affecting their use. R.W.R.

Photoelectric pyrometer. W. R. KING. *Gen. Elec. Rev.*, **39** [11] 526–33 (1936).—The photoelectric pyrometer is a radiant energy-responsive device for indicating or recording the temperature of incandescent bodies. The radiant energy from a hot body is directed to the phototube and causes it to pass a current which bears a definite relation to the temperature of the hot body. This current is amplified by an extremely stable vacuum-tube amplifier, and the amplified current is passed through the indicating or recording instrument. The features and applications of this device are described in detail. Illustrated. L.E.T.

Practical mirror stereoscope for X-ray examination. C. D. MORIARTY. *Gen. Elec. Rev.*, **39** [11] 523–25 (1936).—A mirror stereoscope has been described which is useful for examining X-ray pictures. Its utility is, however, not entirely restricted to that field; the instrument may be used also for reviewing other opaque and translucent pictures. Illustrated. L.E.T.

Pulleys and camber. D. T. ANDERSON. *Brit. Clayworker*, **45** [536] 266 (1936).—It is advisable to install pulleys of as large diameter as service conditions allow with the minimum crown or camber. In some cases the top of the crown can advantageously be turned off to allow a greater width of belt contact. R.A.H.

Radiography as applied to welded boiler drums. E. C. CHAPMAN AND W. L. MARTIN. *Combustion*, **7** [12] 18–23 (1936).—The authors discuss the technique of X-raying welded boiler drums, the function of the Bucky grid in protecting the film from secondary rays, and the development of such equipment up to the 400,000-volt machine lately installed in the Chattanooga works for penetration up to 5 in. of boiler plate. Radiographs showing good and defective welds are reproduced. H.E.S.

Recent advances in crushing and grinding. R. S. DEAN. *Bull. Amer. Ceram. Soc.*, **16** [1] 9–11 (1937).

Studies in filtration: I, Critical analyses of filtration theory. B. F. RUTH, G. H. MONTILLON, AND R. E. MONTONNA. *Ind. Eng. Chem.*, **25** [1] 76–82 (1933).—The derivation of two types of equations governing filtration is reviewed, and their failure to express experimental data adequately is pointed out. The confusion of results obtained by different investigations is shown. The concept of specific resistance is examined and found to be invalid. It is demonstrated that only for incompressible materials is it possible to derive an equation from theoretical grounds, *i.e.*, from Poiseuille's law. The necessity is shown for a study of the early stages of the filtration cycle for a large variety of substances to establish experimentally the exact relation between resistance and the variables affecting it. Illustrated. **II, Fundamental axiom of constant-pressure filtration.** *Ibid.*, [2] 153–61.—It is shown that the irregularities observed in the V^2 *vs.* θ plots at the beginning of filtration are due to the resistance of the filter medium. Further, if this resistance is expressed as units of cake resistance and considered as an integral part of the filtration cycle, the relation of volume and time is shown to be parabolic throughout the whole course of the filtration. The simple equation $(V + C)^2 = K(\theta + \theta_0)$ is shown to hold throughout the whole course of the filtration cycle for a number of types of sludges varying in character from highly rigid to highly compressible particles. Filtration data from many sources in the literature are correlated by the use of this simple equation. This leads to the fundamental axiom of constant-pressure filtration: the time-volume curve of a properly performed constant-pressure filtration forms a portion of a perfect parabola in which the missing portion represents the theoretical course of a similar filtration which would generate a resistance equal to that already existing when the experimentally measured filtrate volume is zero. Illustrated. For Part IV see *Ceram. Abs.*, **15** [6] 186 (1936). F.G.H.

BOOK

Flotation. W. PETERSEN. Theodor Steinkopff, Dresden. Price 19.50 Rm. Reviewed in *Brit. Clayworker*, **45** [536] 284 (1936).—Flotation will become an important refining method for ceramic materials in the future. P. presents the historical development, present stage, and future development of flotation methods. R.A.H.

PATENTS

Apparatus for decorating glassware. E. M. HOMMEL (O. Hommel Co.). U. S. 2,067,447, Jan. 12, 1937 (Aug. 28, 1934).

Continuous rotary filter. C. S. ROBISON (Oliver United Filters, Inc.). U. S. 2,067,415, Jan. 12, 1937 (Dec. 14, 1931).

Molding device. M. S. LANDOW (Pfaltzgraff Pottery Co.). U. S. 2,067,716, Jan. 12, 1937 (July 2, 1935). In apparatus of the class described, a female die having a finishing ring, a male die having a finishing ring, the finishing rings when the dies are in working position being substantially spaced apart, and a resilient member carried by the male die and projecting normally a greater distance beyond the male finishing ring than the depth of the space between the rings when in working relation, the resilient material being squeezed through the space between the rings in working relation to form a part of the molding surface as an extension of the wall of the male finishing ring in alignment with the interior finishing walls of the finishing rings.

Mud gun. E. E. BROSIUS. U. S. 2,065,647, Dec. 29, 1936 (May 29, 1934).

Pneumatic apparatus for separating granular substances. A. B. HELBIG (Victor Balzar Reichwald). U. S. 2,067,321, Jan. 12, 1937 (Dec. 6, 1933).

Process of forming slag blocks. W. C. CORYELL. U. S. 2,067,313, Jan. 12, 1937 (June 29, 1933; May 31, 1935).

Process of treating slag. W. C. CORYELL. U. S. 2,067,312, Jan. 12, 1937 (June 29, 1933). The process of forming a foamlike cellular slag structure from slag in a viscous flowing condition comprises passing the slag in the viscous flowing condition as a continuously flowing stream through a tubular combustion and mixing chamber, and supplying combustion materials to the traveling slag stream near the slag inlet of the chamber, whereby gas is generated and liberated in the traveling slag stream in the chamber to produce a viscous liquid bubbly mass capable of being formed into suitable blocks or slabs.

Kilns, Furnaces, Fuels, and Combustion

Ceramic firing processes: V. OTTO KRAUSE AND EBERHARD KEETMAN. *Sprechsaal*, **69** [40] 579–81; [41] 597–600; [42] 611–13 (1936).—The effect of firing temperature, duration of firing, and furnace atmosphere on (*a*) resistance to pressure, (*b*) color, and (*c*) transparency of various quartz and feldspar bodies was studied. (1) A predominating white color of porcelain can not be obtained with oxidizing atmosphere; a so-called "air yellow" persists. A pure white is obtained only with reduced firing. The white content is stronger, the higher the firing temperature. (2) The longer the firing, the greater is the strength. It is affected by the processes of liquefaction of feldspar, dissolving of quartz, and the state of vitrification depending on the firing treatment of the mix. The rate of the increase in strength increases with increasing feldspar content in the body. Incipient strength increases in proportion to the decrease in porosity with a short firing. (3) With respect to strength properties, bodies with a high quartz content are better than those poor in quartz, but they are more sensitive to long thermal treatment than those rich in fluxes, in which a noticeable decrease in strength occurs even after a short firing. A sufficient strength is obtained in bodies containing from 20 to 30% of undissolved quartz provided that pores do not exceed a definite limit. (4) Transparency is also affected by the processes of feldspar liquefaction and quartz dissolving and therefore by the state of vitrification. The speed with which transparency takes place depends on the increasing vitrification of the body; this is valid for lower temperatures only. At higher temperatures and longer firing time, a partial lowering of transparency takes place which must be ascribed to an increase in porosity produced by gases developed by feldspar. (5) The marked lowering of strength and transparency due to gases from feldspar on longer firing limits the firing time. The effect of pores on electric "shock" is discussed and conclusions with regard to manufacture are drawn. For Part **IV** see *Ceram. Abs.*, **15** [8] 252 (1936). M.V.C.

Coal for brickworks. W. H. GAMBLE AND R. F. PAGET. *Trans. Ceram. Soc.*, **35** [4] 209–18 (1936). **Discussion.** E. ROWDEN, *et al. Ibid.*, pp. 218–19. R.H.H.P., Jr.

Combustion control and controllers. H. C. MITTENDORF. *Combustion*, **7** [9] 20–26 (1936).—Numerous well-known types of combustion control are classified but no attempt is made to describe each in detail; instead, the discussion is confined to the principles upon which they operate and their adaptation to stoker, pulverized-coal, and gas and oil firing. H.E.S.

Continuous furnaces for firing and salting of stoneware. ANON. *Corriere Ceram.*, **17** [10] 301 (1936).—The construction of continuous furnaces in which stoneware is salt-glazed while being fired is given. M.V.C.

Manufacture of salt-glazed stoneware pipes and fittings. A. COULHON. Translated in *Brit. Clayworker*, **45** [536] 256–58 (1936).—C. discusses the firing operation as applied to ceramic ware. Details are given of the reactions and effects of oxidizing and reducing atmospheres on the ware during the firing operation. See *Ceram. Abs.*, **16** [2] 66 (1937). R.A.H.

Physical properties of technical gases. JOSEPH OTTO. *Feuerungstechnik*, **24** [11] 187–89 (1936).—A definition of the physical standard state of gases is given, and the calculation of the molar volume and heating value of gases is dealt with. A table of physical constants of technical gases is given. M.V.C.

Plasticity of coals. R. E. BREWER AND R. G. ATKINSON. *Ind. Eng. Chem., Anal. Ed.*, **8** [6] 443–49 (1936).—Determinations of plastic properties of bituminous coking coals by the revised Davis plastometer and the Agde-Damm and Layng-Hathorne test methods show closer correlation

of data than has been obtained heretofore. Plasticity data from the revised Agde-Damm and plastometer tests enable a fairly reliable prediction of the strength of a coke to be expected from the carbonization of a bituminous coking coal. Illustrated. F.G.H.

Rate of reduction of iron ores with carbon monoxide. Effect of particle size, gas velocity, and gas composition. W. H. WETHERILL AND C. C. FURNAS. *Ind. Eng. Chem.*, **26** [9] 983–91 (1934).—Two new methods of calculating the rate of metallization from gas analysis data are developed. The probable mechanism of the reaction is indicated. New data on the effect of gas velocity, gas composition, and particle size upon the rate of metallization are obtained. The relative rate of reduction and metallization is shown to increase as density decreases. This confirms the work of others. The hypothesis that the metallization zone advances into the ore particle at a constant linear rate is well substantiated. The rate of advance of the metallization zone is shown to be roughly proportional to the square root of the gas velocity. The effect of gas composition upon the rate of metallization is shown for two ores. The rate of metallization decreases as the carbon dioxide concentration increases. Increasing the percentage of carbon dioxide has a different effect upon different ores. The effect of particle size is shown for three ores. The rates vary with size so that the time for complete metallization is practically independent of particle size over the range studied. All three sizes were below 1 cm. in diameter. The time required to reach the composition ferrous oxide is given for the various ores, particle sizes, and gas velocities. The data are not extensive enough to make any prediction as to the mechanism of the first two steps of the reaction. In general, the same factors which cause rapid metallization cause a rapid reduction to ferrous oxide. Illustrated. F.G.H.

Recent developments of low-temperature carbonization of solid fuels in Germany. F. A. OETKEN. Read before meeting of Verein Deustcher Ingenieure, Darmstadt, May, 1936; abstracted in *Eng. Progress*, **17** [10] 229–35 (1936). 14 figures. J.L.G.

BOOKS

Coal: Its Constituents and Uses. WILLIAM A. BONE AND GODFREY W. HIMUS. With supplementary chapter on "Fuel Economy and Heat Transmission in Industrial Furnaces," by Reginald J. Sarjant. Longmans, Green and Co., Ltd., New York, 1936. 631+xvi pages, 22 plates. Price 25s net. Reviewed in *Nature*, **138** [3502] 991–93 (1936).—This is said to be one of the most complete and exhaustive treatises in the English language on the constitution and use of coal. J.L.G.

Heat for Advanced Students. EDWIN EDSER. Revised ed. by N. M. Bligh. Macmillan and Co., Ltd., London, 1936. 487 + x pages. Price 6s. Briefly reviewed in *Nature*, **138** [3501] 952 (1936).—The methods of the calculus have been introduced in the new edition, and the chapter on radiation has been rewritten to include a simple introduction to the quantum theory. J.L.G.

PATENT

Tunnel kilns. SIEMENS-SCHUCKERTWERKE A.-G. Brit. 457,024, Dec. 2, 1936 (July 22, 1935).

Geology

Barytes deposits of Greece. GEO. J. SIOTIS. *Sands, Clays & Minerals*, **3** [1] 43–46 (1936).—Ore deposits, geology, mining methods, and reserves are described. An average analysis of barytes from Milos shows 96.76 $BaSO_4$, 0.88 SiO_2, 0.38 Al_2O_3 + Fe_2O_3, 0.30 loss on ignition, 0.10 H_2O, and 1.58% undetermined. M.H.

Bauxite in France. ANON. *Chimie & Industrie*, **36** [5] 1054–59 (1936).—Deposits of white, red, gray, and refractory bauxite throughout the world are discussed, with special consideration of French bauxites. M.V.C.

Carolina stone. J. H. WEIS AND J. E. BOYD, JR. *Jour. Amer. Ceram. Soc.*, **20** [2] 62–63 (1937).

Clay deposits in Italy. G. CHECCHIA RISPOLI AND M. TARICCO. *Ricerca Sci.*, **2** [7–8] 446–48 (1936).—The different deposits of "Smettic" clays in Italy are enumerated. M.V.C.

Clay prospecting in Montana. J. M. WARDE. *Glück Auf*, **2** [1] 8–10 (1936).—W. reviews existing knowledge of Montana's clay resources. The origin and types of clay deposits in general are discussed. The geologic occurrence of clays in Montana is given with a brief comment on the ceramic raw materials included in the various members of the stratigraphic column. The possibility of the existence of large deposits of residual clay is precluded by the ruggedness of the topography. The Kootenai formation (Lower Cretaceous) and the Fort Union (Tertiary) formation are given as the most promising horizons for commercial clays of sedimentary origin. Criteria are given for clay prospecting, and an outline of the procedure for conducting preliminary tests on clays in the field is included. J.M.W.

Contribution of mineralogy to ceramic technology and research. WILLIAM J. MCCAUGHEY. *Jour. Amer. Ceram. Soc.*, **20** [2] 31–42 (1937).

Crystallography of livingstonite. WALLACE E. RICHMOND. *Amer. Mineralogist*, **21** [11] 719–20 (1936).—The crystallography, cell structure, and space group of livingstonite, a sulfide of Sb and Hg, are presented. F.J.Z.

Mineral resources of Montana. U. M. SAHINEN. *Glück Auf*, **2** [1] 13–15 (1936).—A brief discussion of the metallic and nonmetallic mineral resources of the State supplements the large map of Mont., upon which is plotted the distribution of the mineral wealth of the State. The metallics are, in general, confined to the western and central portion of the State, while the nonmetallics are more uniformly distributed over the entire area. Certain types of products are characteristic of certain areas. Vermiculite, chromite, graphite, corundum, and gypsum are found in the western part; cement materials, coal oil, and gas are found in the central and eastern portions. Clay is found throughout the State. Lack of adequate markets is given as reason for retarded development of nonmetallics in

Mont., but future possibilities are bright for rapid advance along this line. J.M.W.

Modern contributions of science to technique of preparation of clays for the ceramic industry. MAURICE DÉRIBÉRÉ. *Rev. Matériaux Construction Trav. Publics*, No. 323, pp. 113–17B (1936); for abstract see "Preparation—" *Ceram. Abs.*, **16** [1] 49 (1937). M.V.C.

Nonmetallic minerals of Montana. W. W. KRIEGEL. *Glück Auf*, **1** [2] 5 (1935).—A review of the nonmetallic mineral resources of Mont. is given with a graph showing a comparison of the value of nonmetallic and metallic mineral production within the State during the period from 1900 to 1933, inclusive. About 24 manufacturing and processing plants in Mont. are reported utilizing nonmetallics found in the State. Eleven of these operate with local clays to manufacture common and face brick, building tile, flue linings, and drain tile. Two of these plants manufacture clay refractories and one makes silica refractories, both of which are used in local metallurgical and industrial furnaces. Some local plants have produced the cruder types of pottery in the past. Two plants are making Portland cement from the shales and limestones of the State, and several small plants are making concrete products such as pipe, brick, and roofing tile. Several plants manufacturing commercial lime, gypsum, and plaster products are in operation in Mont. The vast sources of cheap industrial fuels and abundant water power are pointed out as having important rôles in the future of the nonmetallics in Mont. The Montana School of Mines and the State Bureau of Mines and Geology are conducting researches in the field of ceramic raw materials within the State, and their studies include the utilization of the chromite deposits, a survey of the clays and clay industry of the State, and a detailed study of the clays of the Kootenai formation in Mont. from which the major clay products manufacturers in the State obtain their raw materials. J.M.W.

Pennsylvania bituminous coals, their classification and analyses. P. B. PLACE. *Combustion*, **7** [10] 33–38; [12] 33–37 (1936).—P. traces individual coal seams through various counties of the State of Pennsylvania and gives their characteristics and identity by county or trade name. The medium and low-volatile coals produced in Pa. are discussed. H.E.S.

Petrologic results of a study of the minerals from the Tertiary volcanic rocks of the San Juan region, Colorado. E. S. LARSEN, JOHN IRVING, F. A. GONYER, AND E. S. LARSEN, III. *Amer. Mineralogist*, **21** [11] 679–701 (1936).—These Tertiary volcanic rocks contain silica minerals, such as tridymite, quartz, and cristobalite. The conditions of crystallization for these silica minerals together with the formation of pyroxenes and olivines are thoroughly discussed. F.J.Z.

Physical properties of certain iron oxides. W. H. NEWHOUSE AND J. P. GLASS. *Econ. Geol.*, **31** [7] 699–711 (1936).—An oxidation product of magnetite was studied by means of polished sections and X-ray diffraction patterns. Chemical analyses of mixtures of this mineral and magnetite are given. The mineral agrees in properties with the unanalyzed mineral maghemite of Wagner and Schneiderhohn. The magnetic properties of the powdered mixtures indicate a high coercive force which may be due to the fine-grained structure of the mineral. The composition of the new mineral varies from $(FeTi)_3O_4$ to Fe_2O_3. J.L.G.

Quality of "Toseki" or semi-decomposed feldspathic rocks and their uses: I. SHINICHIRO OGAWA AND ATSUJI TERAZAKI. *Jour. Japan. Ceram. Assn.*, **44** [522] 394–400 (1936).—In Japan, half-decomposed liparite and andesite are indispensable raw materials for whiteware. The paper relates to the comparison of recently discovered "Toseki" with Amakusa stone which is best in quality and is most extensively used. Amakusa stone is sold in 9 grades. The superior grade has a specific gravity of 2.68; ferric oxide content is 0.28%. It contains only a trace of titanium and has no manganese and sulfide. Shrinkage at cone 12 is 8.6%. It is whiter at cone 12 than at cone 10; P.C.E. is cone 26. The calculated mineral composition is quartz 57.6, kaolinite 17.9, sericite 16.7, feldspar 7.4, and other constituents 0.4%; under the microscope, a small amount of pyrophyllite is observed. S.K.

Quartz sand, ground sand, and flint in enamel industry. W. REINER. *Illustr. Ztg. Blechindustrie*, No. 21, p. 631 (1936); abstracted in *Glashütte*, **66** [44] 743 (1936).—Sand is a mineralogical and not a chemical term. It is a more or less finely granulated material consisting chiefly of quartz, *i.e.*, chemical silica. It is a hard, natural, pulverized rock and is a product of weathered rocks rich in quartzite. Flint is composed of finely crystalline and amorphous silica. It is found chiefly in the chalk deposits of northern France and in chalk rocks of England and the Danish Islands. M.V.C.

Silica. VIELHABER. *Emailwaren-Ind.*, **13** [37] 299–300 (1936).—The general properties of silica are dealt with. M.V.C.

Size distribution of minerals in Mississippi sands. R. DANA RUSSELL. *Jour. Sed. Petrology*, **6** [3] 125–42 (1936).—Sediment samples from the bed of the Mississippi River vary considerably in grain size and degree of sorting. These variations cause such differences in mineral composition that accurate mineralogical comparison of the samples is not possible on the basis of the usual methods of analysis and comparison. It is suggested that in such samples a single size grade from each sample be used as a basis of analysis and comparison of the light minerals, provided the grade represents the average composition of the light portion. In the case of the heavy minerals, two size grades should be averaged for each sample. One of these grades should be the same for all samples. The other should represent a definite position with respect to the size-frequency distribution of the sample. G.M.H.

Soils. G. W. ROBINSON. *Sands, Clays & Minerals*, **3** [1] 35–38 (1936).—The study of soil as developed in recent years (pedology) is discussed and defined. Soil consists essentially of mineral matter and organic matter. The international scale defines the constituents as follows:

Coarse sand	2.0–.02	mm. in diam.
Fine sand	0.2–.02	
Silt	0.02–.002	
Clay	Less than 0.002	

A typical analysis of several soils shows the following results:

	Sandy loam	Light loam	Heavy loam	Clay	Heavy clay
Coarse sand	66.6	27.1	13.6	0.9	1.0
Fine sand	17.8	30.3	17.4	7.1	4.1
Silt	5.6	20.3	24.7	21.4	7.9
Clay	8.5	19.3	35.1	65.8	82.8
Organic matter, carbonates, etc.	1.5	3.1	9.2	4.8	4.2

Below the 0.002-mm. limit the material consists mainly of (1) montmorillonite-beidellite minerals, (2) halloysite-kaolinite minerals, and (3) hydrated ferric oxide and alumina; (1) and (3) are chemically the most reactive, and, as a whole, the clay complex has a greater reactivity than the silt and sand fractions. The soil organic matter consists mainly of dark-colored amorphous material, known as humus, which forms the colloidal complex of the soil. The base exchange properties are explained and represented by the two principal reactions, Ca soil + 2NaCl = 2Na soil + $CaCl_2$, and H soil + NaCl = Na soil + HCl. A typical diagram of the stratification of a podsol soil is given. See *Ceram. Abs.*, **15** [11] 347 (1936). M.H.

Spectrographic examination of Siamese zircons. T. G. Kennard and David H. Howell. *Amer. Mineralogist*, **21** [11] 721–26 (1936).—No differences in chemical composition were found by spectrographic examination of inclusion-free portions of brown, blue, and colorless Siamese zircons. Black inclusions and red spots contained iron and sometimes Al, Cu, and Ti. The blue and brown colors in the inclusion-free zircons are not pigmental, but may be due to structure or colloids. F.J.Z.

Structure and chemical composition of glauconite. P. P. Filipenko. *Bull. Mosk. Obchtcht. Ispytat. Prirody (Gueol.)*, **43** [13] 155–69 (1935); abstracted in *Chimie & Industrie*, **36** [3] 518 (1936).—Glauconite is a microscopic nonhomogeneous mixture of at least two minerals; it does not behave according to any definite stoichiometrical formula. One of the constituents of glauconite is the opal of the composition $2SiO_2 \cdot H_2O$; the other constituent is an aluminoferrate acid, $2R_2O_3 \cdot pR'_2C$, in which R is Al and F‴, p = 2; 3; 4 + R′ = H:K; K; Li; Na; Mg; Ca; Fe″. The composition of glauconite can be expressed by the general formula m [$2SiO_2 \cdot H_2O$] + n [$2R_2O_3 \cdot pR_2O$]. No determined relation exists between m and n. It is possible to isolate three types of glauconites: (1) R_2O_3: R_2O = 1:1. This is the rarest type. (2) R_2O_3:R_2O = 1:1.5. (3) R_2O_3:R_2O = 1:2. Lithium is the characteristic constituent of glauconites. Following the disintegration of glauconite from the action of atmospheric factors, hydrated silica and hydroxides of iron and aluminum are obtained as the final products. M.V.C.

Study of bauxite deposits in France. V. Charrin. *Argile*, No. 164, pp. 3–7 (1936).—The question of the origin of bauxite is discussed. M.V.C.

Synthesis of montmorillonite. W. Noll. *Chem. Erde*, **10** [2] 129–54 (1936).—Experiments to synthesize montmorillonite from aluminum hydrate and silica gel, using a steel pressure bomb with a platinum crucible in the presence of water at a temperature of 300°C and a pressure of 87 atmospheres, gave the following results: Montmorillonite can be synthesized hydrothermally from alumina and silica hydrates in the presence of hydroxides as well as carbonates, sulfates, and chlorides of the alkalis and alkaline earths. Hydroxides of these substances react approximately quantitatively to form montmorillonite at the molecular ratio R'_2O (or R″O): Al_2O_3:SiO_2 = 0.2:1:4. In the presence of carbonates, sulfates, and chlorides, more or less kaolinite is formed as well as montmorillonite. With decrease of the hydroxide concentration, montmorillonite is replaced by kaolinite. With increase of the hydroxide concentration, new phases appear (analcite in the case of Na_2O) when the ratio of R'_2O (or R″O):Al_2O_3 for Na_2O, K_2O, or CaO becomes 1:1 or greater, while for MgO this is not true. Of these only Mg is taken into the montmorillonite lattice. From these experiments it is suggested that montmorillonite is found in nature where the alkalis are not completely leached from the parent rock, where the reacting solutions are alkaline, and the circulation of the solutions is poor, whereas kaolinite is formed where the solutions are acid, the circulation good, and the concentration of alkalis very low. In sodium-bearing alkaline systems in nature, montmorillonite takes an intermediate position between kaolin formation and zeolite formation with reference to sodium concentration. See also *Ceram. Abs.*, **15** [2] 72 (1936). H.I.

Transformation of pyroxene peridotites into siliceous and ferruginous rocks, especially in the basin of Lulua and Bushimaie. Ed. Polinard. *Publ. Congo Belge Regions Voisines*, **59**, 19–33 (1936); abstracted in *Chem. Zentr.*, **ii**, 1139 (1936).—The transformation begins with the decaying of Mg minerals into serpentine. With the progress of disintegration, serpentine is displaced or driven out by chalcedony, quartz, and opal, besides oligoclase and magnetite. Chemically the total MgO and a part of FeO, Al_2O_3, and CaO are separated. M.V.C.

Two diopsides from southern California. Richard Merriam and J. D. Laudermilk. *Amer. Mineralogist*, **21** [11] 715–18 (1936).—Exceptionally pure diopsides occur in the limestone contact zones at Crestmore, near Riverside, and at Cascade Canyon, near Upland, Calif. Chemical analyses and optical properties of both samples, especially that from Cascade Canyon, are close to published values for artificial diopside. F.J.Z.

X-ray determination of silica minerals in submicroscopic intergrowths. Cornelius S. Hurlbut, Jr. *Amer. Mineralogist*, **21** [11] 727–30 (1936).—The application of photodensitometric measurements of X-ray diffraction patterns to the identification of the silica minerals, quartz, cristobalite, and tridymite, as they often occur in submicroscopic intergrowths with feldspar and other minerals, is discussed. Powder diffraction patterns and photodensitometer records of spherulites from four rhyolites indicate the presence of cristobalite and perthite. F.J.Z.

Zircon as a ceramic material. George C. Betz. *Foote-Prints*, **9** [2] 15–24 (1936).—Applications of purified zircon to electrical and chemical porcelains, refractories, glasses, enamels, and cements are discussed. A. P.

BOOKS AND BULLETINS

British Regional Geology: London and Thames Valley. R. L. Sherlock. Department of Scientific and Industrial

Research, Geological Survey, London, 1935. Price 1s 6d.—A geological survey is given of an area composed chiefly of clays, gravels, sands, and chalk, the Reading beds, Gault, and London clay being the most important ceramic materials. These are only briefly described, but the maps and diagrams show the area they occupy. **Northern England.** T. EASTWOOD. Price 1s 6d.—A geological survey is given of an area rich in fire clays, graphite, barytes, witherite, fluorspar, gypsum, and silica as well as shales and clays suitable for common brick. The diagrams and maps are on too small a scale to show the locations of these materials. **South-West England.** H. DEWEY. Price 1s 6d.—A geological survey of Devon and Cornwall is given including the well-known areas in which ball clay, china clay, china stone, and slate occur. These are very briefly mentioned, the greater part of the volume being devoted to igneous rocks. No mention is made of the fire clays occurring in Cornwall. The book is well illustrated. **Central England District.** F. H. EDMUNDS AND K. P. OAKLEY. *Ibid.*, 1936. Price 1s 6d net.—A geological survey is given of the Midlands of England which consist chiefly of Liassic and Triassic rocks with some Coal Measures. Although this area includes the Staffordshire Potteries, the whole of the information about fire clays is confined to seven lines. The Oxford clay, from which 2,400,000,000 brick are made annually by one group of firms, is allotted more than half a page and none of the fossils mentioned are those characteristic of the "Knotts" beds used for brickmaking. The book is well illustrated by photographs and diagrams. A.B.SEARLE

Chromite. ROBERT H. RIDGWAY. Reprint from U. S. Bur. Mines Minerals Yearbook, 1936. Supt. of Documents, Govt. Printing Office, Washington, D. C. 11 pp. Price 5¢. R.A.H.

Feldspar. R. W. METCALF. Reprint from U. S. Bur. Mines Minerals Yearbook, 1936. Supt. of Documents, Govt. Printing Office, Washington, D. C. 16 pp. Price 5¢. R.A.H.

India's Mineral Wealth. J. COGGIN BROWN. Oxford Univ. Press, 1936. 308 pp., 2 appendixes, 6 maps, and 8 plates. Price 10 Rs. B. gives detailed and up-to-date information of all the important minerals of India and Burma, their occurrences, uses, production, and general economics with short accounts of the mining and metallurgical industries based upon them. This is a valuable reference book. A.P.SOM

Mineral Resources of the Region around Boulder Dam. D. F. HEWETT, EUGENE CALLAGHAN, B. N. MOORE, T. B. NOLAN, W. W. RUBEY, AND W. T. SCHALLER. *U. S. Geol. Survey Bull.*, No. 871, 197 pp. Price 45¢. The mineral resources are considered in three groups: nonferrous-metal group, ferrous-metal group, and the nonmetallic group. The bulk of the report consists of descriptions of the several districts, with statistics of production. Detailed studies were made in the magnesite area of Muddy Mountains, the borate area near Kramer, and the celestite area near Ludlow. R.A.HEINDL

Summary of Progress of the Geological Survey of Great Britain: I, 1935. H. M. Stationery Office, London, 1936. Price 1s 6d. Attention is called to the centenary of the Geological Survey, and the work done by the Officers of the Survey during 1935 is summarized. None of it relates specifically to clays beyond a statement that "certain British clays have been sent to the Chemical Research Laboratory for treatment as water-softeners" and a further statement that reserves of fuller's earth have been the subject of frequent inquiries. A.B.SEARLE

Talc and soapstone. ALDEN H. EMERY AND B. H. STODDARD. Reprint from U. S. Bur. Mines Minerals Yearbook, 1936. Supt. of Documents, Govt. Printing Office, Washington, D. C. 9 pp. Price 5¢. R.A.H.

Chemistry and Physics

Analysis of calcium fluoride. A. K. KUDREVATOV. *Compt. Rend. Acad. Sci. U.R.S.S.*, **4** [1–2] 42–43 (1934).—CaF_2 dissolves easily if heated in concentrated HF in the presence of chlorides, $CdCl_2$, $ZnCl_2$, $NiCl_2$, etc. Complex salts of different stabilities are obtained. Calcium oxalate for oxidimetric determination can be with difficulty separated from such a solution. Satisfactory results are obtained by using as a solvent metal chlorides whose oxalates readily dissolve in water. Best results can be obtained with Mg and Li. The gravimetric method (precipitation of Ca by H_2SO_4 in the presence of alcohol in sulfate form) gives more precise results. P.B. & E.S.

Contributions to microsilicate analysis. KARL SCHOKLITSCH. *Mikrochemie*, **20**, 247–53 (1936).—S. deals with the determination and separation of iron, aluminum, magnesium, calcium, titanium, and manganese, which, together with SiO_2, are the most important elements in silicate analysis. New microanalytical methods are described. A red clay and another mineral (omphazite) have been analyzed, and results for macro- and microanalyses are given. Both check very closely. Further work on microsilicate analysis is carried on at the University (Graz, Austria). L.E.T.

Determination of semi-microquantities of phosphates. N. HOWELL FURMAN AND HAROLD M. STATE. *Ind. Eng. Chem., Anal. Ed.*, **8** [6] 420–23 (1936).—A new complex compound, $[Co(NH_3)_5NO_3]H_3PMo_{12}O_{41}$, has been prepared and analyzed and applied to the determination of semimicroquantities of phosphate. The method has been applied to the estimation of phosphorous pentoxide in phosphate rocks. F.G.H.

Determining zinc as zinc oxide in the presence of ammonium salts with a preliminary precipitation as zinc carbonate. N. A. TANANAEV AND L. T. EREMENKO. *Zavodskäya Lab.*, **3** [2] 114 (1934).—The precipitation is to be fulfilled according to the rule of crystalline precipitates. The sample is dissolved in an excess of acid; an excess of ammonia, some drops of phenolphthalein, formaldehyde, and 20% NaOH solution are added until the solution colors red and obtains an odor of formaldehyde. HCl is added until a feeble reaction appears, and water is added up to 100 cc.; the mixture is treated to the boiling point. The precipitation is effected slowly by a device for the precipitation of crystalline precipitates by a hot soda solution with rapid stirring. In cases where zinc is separated from other cations in the form of an ammonia

complex, the precipitation can be fulfilled according to the rule of amorphous precipitates, but in this case the results obtained are too high on account of the adsorption by the soda precipitate. P.B. & E.S.

Dissociation of magnesium chromate. I. G. Ryss and P. G. Uritzkaya. *Compt. Rend. Acad. Sci. U.R.S.S.*, **4** [4] 213–17 (1934).—Pure anhydrous magnesium chromate was obtained by treatment on a water bath of c.p. magnesium oxide by a stoichiometric solution of c.p. chrome anhydride and by recrystallization of the product obtained after filtration. The thermal dissociation of magnesium chromate takes place according to the following equations: (1) $2MgCrO_4 = 2MgO{\cdot}Cr_2O_3 + 1.5O_2$; and (2) $2MgO{\cdot}Cr_2O_3 = MgO + MgO{\cdot}Cr_2O_3$. The second reaction is favorably influenced by an increase of temperature. In a hydrogen current, an energetic reaction with flames takes place at about 300°. Doerner's statement of a partial oxidation of a mixture of magnesium and chrome oxides at 830 to 1000° has not been confirmed. The dissociation pressures of magnesium chromate, measured by the static method, are expressed by the equation $\log Pmm = 16{,}488/T + 23{,}271$; the computed heat of dissociation is equal to 75,370 cal./mol. P.B. & E.S.

Double layer of clay colloids. A. L. S. Bär and H. J. C. Tendeloo. *Kolloid-Beihefte*, **44**, 97–124 (1936).—To hold a substance in solution, it must be surrounded with an electrical double layer. The inner layer consists of ions (hydroxyl) which possess a lattice energy greater than their hydration energy. Experiments were carried out on 11 ball clays, one bentonite, and other soils. Humus was destroyed with H_2O_2, and then a treatment of HCl (0.05 *N*) dissolved any $CaCO_3$ present. By sedimentation all coarse particles were removed, and fractions $< 10\ \mu$ were kept for further test. Free quartz and other impurities were determined qualitatively by X-ray. The materials were mixed with flint and treated with 0.05 *N* Ca-acetate in percolator tubes. Acetic acid was added to make up six groups ranging in p_H value from 4.7 to 7.8. The results are shown in 12 tables, giving average increase in exchange capacity per unit at p_H value of 4.7. L.E.T.

Effect of clay stabilizers. Aladár Foeldvári. *Kolloid-Beihefte*, **44**, 125–70 (1936).—Materials used for stabilizing clay suspensions may be divided into groups as follows: (1) materials or solutions which bring about adsorption of OH ions and electrical charge, causing stabilization, such as bases, alkaline carbonates, and alkaline salts of weak organic acids; (2) stabilizers which remove coagulating ions from the suspension, *e.g.*, sodium oxalate; in clays Ca ions have very strong coagulating action; and (3) peptonizers, which coat the fine particles with a protective skin and thereby remove coagulating ions, *e.g.*, (Schutzkolloide) sodium metasilicate (water-glass). Sedimentation tests were made on a series of clays, chalk, etc. Sodium oxalate (0.005 *N*) gives best dispersion for most minerals. In clays where $CaCO_3$ or $CaSO_4$ is high, water-glass gives best results. 28 references. L.E.T.

Effect of temperature and electrolytes on the plastic properties of kaolin. M. P. Volarovich and D. M. Tolstoi. *Compt. Rend. Acad. Sci. U.R.S.S.*, **1** [9] 557–60 (1934).—The effect of temperature and electrolytes on the constants ϑ (yield value) and η (inverse value of "mobility") of the Bingham equation $F/S\,\vartheta = \eta\, dv/dx$ was investigated by the concentric cylinder method developed by the authors. In the interval 10 to 57 °C, ϑ is independent of the temperature, and η falls with the increase of temperature at a lower rate than the viscosity of water. NaOH reduces both constants considerably, and NaCl leads to a slight fall of ϑ and a considerable rise of η. The plasticity expressed by ϑ/η falls in both cases. P.B. & E.S.

Efflorescence of salts. Karl Schulze. *Kolloid-Beihefte*, **44**, 2–91 (1936).—S. deals with efflorescence of soluble salts, such as occur on soils, ceramic materials, and finished products. The different types of scums, factors causing them, shapes and crystals, and their growth are discussed and illustrated. 163 references. L.E.T.

Electrolysis of aluminum silicates. N. S. Fortunatov. *Ukrain. Akad. Nauk, Zapiski Inst. Khem.*, **2**, 257–59 (1935); abstracted in *Chem. Zentr.*, **ii**, 506 (1936).—Attempts to separate Al from solutions of aluminum silicates in fused alkalis are described. It was found that Si is separated during electrolysis on the cathode but Al is not. The decrease of the Si content in the melt is, however, followed by a precipitation of aluminates from it; hence it is possible to obtain aluminates from aluminous silicates by electrolysis. M.V.C.

Falling velocities of minerals through water. W. Miller and T. W. M'Inally. *Jour. Roy. Tech. Coll.* [Glasgow], **3** (Part 4) [1] 682–89 (1936).—Tests were made for the effect of shape on the speed of fall of materials in water. A variety of materials and shapes was tested, and the results are given in curves and tables. W.H.B.

Formation of mixed crystals with tin monoxide. E. Hayek. *Monatshefte Chem.*, **66**, 197–200 (1935).—Tin monoxide, SnO, when crystallized from aqueous solution, forms mixed crystals with Pb, Mn, Fe, Cd, and Ca oxides. Pure SnO has a blue-black color but the addition of small amounts of other oxides produces characteristic colors. The limits of solubility in SnO and colors of the mixed crystals are as follows: Pb, 4.3%, yellow-green metallic; Mn, 2.3%, brownish violet; Fe, 2.1%, brownish; Cd, 1.1%, silver-gray; CaO, 0.05%, silver-gray. CoO, NiO, MgO, SrO, and BaO do not form mixed crystals. Pure SnO, which is opaque in a thickness of 0.05 mm., is transparent in crystals 0.2 mm. thick when containing only 1% CdO. The crystals containing Cd, Fe, Mn, and Pb were examined by the X-ray powder method. Only those containing Pb showed appreciable alteration in structure. R.F.R.

Progress in the technique of crystal analysis. William Bragg. *Nature*, **138** [3501] 953–54 (1936).—B. cites instances in which improvement in X-ray crystal-analysis technique has determined doubtful structures. Measurements of the dimensions of the unit of pattern of a structure can now be made to an accuracy of one part in several thousand. Atomic distances in the unit cells can be measured to an accuracy of about 1% even in the complicated molecules of organic crystals. See "Structure-factor graphs—" *Ceram. Abs.*, **16** [1] 46 (1937). J.L.G.

Rapid method for determining insoluble residues in limestones, dolomites, and Ural iron ore. V. D. Voznesenskiĭ and A. B. Gurevich. *Zavodskaya Lab.*, No. 9, pp. 40–45 (1933).—Ore in amount of 0.5 g. is ground and dried at 105 °C and is dissolved in a boiling water bath;

the solution is diluted with water and filtered through a dense filter. After the filter is twice washed out with dilute hot HCl to remove the excess of iron salts, the precipitate is washed out with dilute HCl until the reaction on iron disappears. The remainder is calcined together with the filter, ignited for 5 min., and weighed upon cooling. The difference between the weight of the empty crucible and its weight when containing the residue, divided by the input and multiplied by 100, gives the weight of the insoluble residue in the material investigated. The whole analysis takes $1^1/_2$ to 2 hr. instead of 4 to 5 and simplifies the equipment required. P.B. & E.S.

Standard liquids for the microscopic determination of refractive index. A. H. KUNZ AND J. SPULNIK. *Ind. Eng. Chem., Anal. Ed.*, **8** [6] 485 (1936).—The preparation of a set of organic liquids for the microscopic determination of refractive index by the Becke line method is briefly described. F.G.H.

Theory of reflection of X-rays by crystals. C. MAUGUIN. *Jour. Phys. & Radium*, **7** [6] 233–42 (1936).—Mathematical theoretical treatment is presented. See *Ceram. Abs.*, **15** [10] 312 (1936). F.P.P.

Thermal disintegration of Na_2SO_4 in the presence of SiO_2 and kaolins. Y. A. FIALKOV AND S. D. SHARGORODSKII. *Ukrain. Akad. Nauk, Zapiski Inst. Khem.*, **2**, 269–83 (1935); abstracted in *Chem. Zentr.*, **ii**, 598 (1936).—The effect of various factors on the thermal disintegration of Na_2SO_4 in the presence of SiO_2, kaolins, and other oxide additions was studied. Conclusions are as follows: (1) The disintegration of Na_2SO_4 with SiO_2 addition increases with increased temperature; a marked disintegration occurs with the ratio of Na_2:SiO_2 = 1:3 at 100°. The degree of disintegration increases with increased degree of dispersion of SiO_2. (2) Among oxides studied (TiO_2, Fe_2O_3, CeO_2, Cr_2O_3, Al_2O_3), the most effective are CeO_2, TiO_2, and Fe_2O_3. (3) Among technical products kaolins are very effective; various kaolins act differently. The best proportion of Na_2SO_4 to kaolin is 1 to 4. (4) The reaction products of the disintegration of Na_2SO_4 with kaolin consists of O_2 and SO_4 (gases) and aluminate, silicate, and sodium aluminum silicate in the melt. These experiments show that it is possible to manufacture H_2SO_4, Al_2O_3, and Na_2CO_3 when thermally treating Na_2SO_4 with kaolin. M.V.C.

Transformation of zircon dioxide. A. GAMBEY AND G. CHAUDRON. *Congr. Chim. Ind., 14th Congress, Paris, 1934*, **1**, 5 pp. (1935); abstracted in *Chem. Zentr.*, **ii**, 27 (1936).—Dilatometric studies showed the transformation of ZrO_2 taking place at 1000°. At 1800° ZrO_2 forms, with MgO, CaO, and CeO_2, solid solutions which are stable between 20 and 1800° and whose coefficient of expansion is of the same order of magnitude as that of quadratic ZrO_2. M.V.C.

BOOK

Comprehensive Treatise on Inorganic and Theoretical Chemistry: Vol. XV, Ni, Ru, Rh, Pd, Os, Ir. J. W. MELLOR. Longmans, Green and Co., Ltd., New York, 1936. vii + 816 pp. Price 63s net. Briefly reviewed in *Nature*, **138** [3486] 310 (1936).—M. is to this generation what Roscoe and Schorlemmer were to the last. He is prepared for any question we care to put to him. The final and index volume of this work is now in the press. For Vol. **14** see *Ceram. Abs.*, **14** [10] 262 (1935). H.H.S. + J.L.G.

PATENTS

Crystalline anhydrous borax. L. G. BLACK (American Potash & Chemical Corp.). U. S. 2,064,337, Dec. 15, 1936 (March 7, 1931). A new product consists of anhydrous borax, substantially all particles of which are present as crystals.

Direct process for making sodium perborate. J. S. REICHERT (E. I. du Pont de Nemours & Co.). U. S. 2,065,744, Dec. 29, 1936 (May 27, 1932). A process for the manufacture of alkali metal perborates comprises reacting a boric acid derivative selected from the group which consists of boric acid, boric anhydride, and alkali-metal borates, in the solid state, with an alkali-metal peroxide and a solution of hydrogen peroxide in the requisite proportions at a temperature below 80°C, the total amount of combined and uncombined water present in the reaction mixture being limited to not more than 8% in excess of the amount required to form the completely hydrated final product.

Method of producing crystallized anhydrous sodium metasilicate. C. L. BAKER (Philadelphia Quartz Co.). U. S. 2,067,227, Jan. 12, 1937 (Nov. 25, 1933). The method of making anhydrous crystalline sodium metasilicate comprises preparing a solution of sodium metasilicate containing upward of approximately 50% of sodium metasilicate, agitating and heating the solution to a temperature upward of 90°C until crystals of anhydrous sodium metasilicate appear, and drying the mass by continuing the heat and adding a compatible alkali-metal compound capable of absorbing excess water to form a solid.

Process for the separation of cadmium from its ores. R. W. HYDE. U. S. 2,064,835, Dec. 22, 1936 (Aug. 8, 1935).

Sodium aluminate. DAVID LURIE (American Cyanamid & Chemical Corp.). U. S. 2,066,209, Dec. 29, 1936 (Oct. 17, 1934).—A method of making sodium aluminate includes the steps of digesting an aluminum-bearing earth with an amount of caustic liquor in excess of that theoretically necessary to react with the quantity of earth added, separating the solid residue from the liquid reaction product, adding an additional quantity of aluminum-bearing material uncombined with alkali metal to the liquid reaction product, and subjecting the same to heat to cause further reaction between the aluminum-bearing material and the caustic and to remove water.

General

Application of colloidal chemistry to boiler water conditioning. L. D. BRETZ AND R. T. SHEEN. *Combustion*, **7** [11] 39–41 (1936).—Organic materials have long been used either alone or in combination with various inorganic precipitants for correction of boiler feedwater. The lack of quantitative data is marked, and the action of this

class of materials has been more or less obscure. This paper deals with a class of colloids that possess a definite reaction with calcium and magnesium salts. H.E.S.

Boilers with forced circulation. F. MUNZINGER. *Combustion*, **7** [8] 23–28 (1936).—A critical examination of the essential characteristics of the various types of boilers, including both forced and natural circulation, and the influence of high pressures on the design is presented. Forced circulation is discussed at length and a distinction is made between it and forced flow. The present large number of boiler types is indicative of a transition period, and M. points out the trend of future development. H.E.S.

Bubbles in ceramic bodies. W. SCHUEN. *Keram. Rundschau*, **44** [28] 327–29; [29] 341–42 (1936).—Bubbles are found in all kinds of ceramic bodies, particularly in stoneware. S. gives four causes as follows: (1) small quantities of air carried from the press by fat mixtures; (2) larger quantities of air driven by mixtures of ordinary composition; (3) iron peroxide reduced by carbon or decomposed at high temperatures or steam evolved in the sintering or melting zones; and (4) gas evolved by overheating. F.E.V.

Cantieny boiler. ANON. *Combustion*, **7** [9] 40 (1936).—The design of the Cantieny boiler for high pressures ranging from 600 to 1950 lb./sq. in. and outputs up to 350,000 lb. of steam/hr. is illustrated and discussed. The essential features of this design center about the circulation system, the aim being to secure, with natural circulation, a positive flow with high pressures and to avoid priming or carry-over when the boiler water contains a high concentration of solids. H.E.S.

Coördination of boiler auxiliaries. A. F. SPITZGLASS AND G. K. O'CONNOR. *Combustion*, **7** [12] 25–26 (1936).—The most difficult problem in the application of combustion control to boilers is the proper coördination of the fuel-burning auxiliaries to obtain accurate and efficient control of steam pressure, combustion, and furnace draft. The authors discuss this with reference to boilers fired by stokers, pulverized coal, gas, and oil. H.E.S.

De-airing clays with butane. ANON. *Rev. Matériaux Construction Trav. Publics*, No. 326, pp. 161–63B (1936).—In the study of de-airing clay by displacing the air inclosed by means of a gas such as methane, propane, pentane, heptane, butane, and CO_2, it was found that butane, C_4H_{10}, gave the best results in preventing fissures due to pressure and in increasing the rupture modulus and resistance to compression. Laboratory experiments have been supplemented by tests in industry by the Harbison-Walker Refractories Co., the Pyro Clay Products Co., and others. Tables of the results show that also under industrial conditions de-airing with butane improves all physical properties of brick except spalling. M.V.C.

Dust control in the fine-ceramics industry. FR. PROCKAT. *Staub*, No. 2, pp. 175–201 (July, 1936).—P. calls attention to processes in the ceramic industry which are carried on in dangerous dusts, considering each in turn: (1) refining and comminuting of raw materials (2) turning, bordering, and surfacing of dry crude porcelain (3) dusting-off of dried porcelain by pneumatic pressure before glazing, (4) turning, shaping, and drying of crude porcelain, indirectly producing dust, and (5) spraying for color or glaze. The importance of dust control in this industry is shown in the fact that the German Pottery Insurance Society paid out more than half its total income in 1933 for pensions and expenses of severe silicosis. Instead of treating every dust-producing process in the industry, P. emphasizes a series of mechanisms tested out as effective or ineffective in controlling dangerous dust, urging coöperation between workers and the practical engineer in running the business economically and preventing silicosis. Twelve photographs of properly equipped workrooms and 13 working drawings of dust-control appliances are included. K.R.

Estimation of dust in mine atmospheres. A. M. BRYAN AND J. SMELLIE. *Jour. Roy. Tech. Coll.* [Glasgow], **3** (Part 4) [1] 671-81 (1936).—Dust measurement and abatement are discussed, and figures are given for various parts of the mine. W.H.B.

Large steam generating unit at Ottumwa plant of John Morrell & Co. P. R. WALTER. *Combustion*, **7** [8] 35–37 (1936).—This new pulverized coal-fired unit of 170,000 lb./hr. output, which replaces four old units, has capacity sufficient to carry the total steam load of the plant 75% of the time. It consists of a four-drum bent-tube boiler of the multiple-circulation type designed for 448-lb. pressure, a plate-type air heater, and fin-tube furnace of the dry-bottom type. Iowa coal of 15% moisture is burned with a maximum heat liberation of 20,800 B.t.u./cu. ft., and the gases, after leaving the air heater, pass through a "multi-cyclone" fly-ash eliminator to a 200-ft. stack. H.E.S.

Malaxing of clays. Aërodynamic blades. P. S. *Rev. Matériaux Construction Trav. Publics*, No. 326, pp. 164–65B (1936).—With the modified form of blade (the aërodynamic) for working clay, thorough kneading is assured and the clay advances without raising the temperature. When malaxage is complete, as in this case, the percentage of waste is lowered. Illustrated. M.V.C.

Organizing plant instrument services. ALFRED G. MOON. *Instruments*, **9** [12] 331–34 (1936).—M. discusses the organization of a plant instrument department, forms used, and selection of personnel. R.W.R.

Prevention of lead sickness in manufacture of tile and pottery glazes. C. STÜRMER. *Keram. Rundschau*, **44** [39] 465–66 (1936).—Some large German firms have elaborated lead silicate compounds of known composition and very small tolerance, intended for every kind of ceramic glaze. Manipulation of these compounds is free from danger. The acetic test shows that glazes containing $PbO{\cdot}2.5SiO_2$ are chemically the most resistant. A mixture of $PbO{\cdot}2SiO_2$, 5% kaolin, and 5% quartz or feldspar fired at cones 05*a* to 03*a* is quite satisfactory. Although lead content is lower, the aspect is better than with former mixtures. F.E.V.

Progress of ceramic education at Montana School of Mines. J. M. WARDE. *Glück Auf*, **1** [4] 5–6 (1936).—A résumé of the history of ceramic education at the Montana School of Mines covers the period from the first introduction of a general ceramics course into the curriculum in 1932 up to the activities of the present division of ceramics. An excellent ceramics products museum has been assembled, and the facilities of the school library in the field of ceramics have been expanded. The new equip-

ment constructed and that acquired by donations are described, including a downdraft test kiln, decorating kiln, mercury volumeter, oxyacetylene fusion furnace, tensile strength-testing equipment, ball mills, jigger wheel, enameling materials, and clays. With these materials and equipment the Montana School of Mines is able to widen its scope of ceramic investigation, and the installation of an adequately equipped ceramics testing laboratory has been of great assistance to the prospectors and local ceramic manufacturers of Mont., to whom its services are free. Research on the possible utilization of the chrome reserves of the State as ceramic materials is in progress. A clay survey of the State is being made, and a report is to be published by the State Bureau of Mines and Geology on the clays and clay industry of the State. A detailed study of the Kootenai formation, Montana's most important clay horizon, is being conducted. J.M.W.

Studies at the State Research Bureau for Silicate Industry. OTOKAR KALLAUNER. *Zprávy Československ. Keram. Společnosti*, **11**, 24–40 (1934); abstracted in *Chem. Zentr.*, **ii**, 2865–66 (1935).—The studies mentioned are (1) Sorel cement, (2) determination of FI, (3) rational analysis of kaolin earth, (4) thermal disintegration of chlorite, and (5) thermal disintegration of steatite. M.V.C.

Technical Congress of the French Ceramic Industry. A. C. *Rev. Matériaux Construction Trav. Publics*, No. 322, pp. 100–103B (1936).—Abstracts of the following papers read at the Congress in Paris, May 25–26, 1936, are given: (1) "Technique and control of the operation of discontinuous furnaces," by Victor Bodin and P. Gaillard; (2) "Researches on the aging of clays," by Pierre Bremond; (3) "Application of a capillary method for the study of the change of enamels and glazes by chemical reagents," by René Dubrisay, Henri Lafuma, and Martha Pavlousky; (4) "Defects in ceramic stoneware tile, their causes and effects," by Felix Chalamel; (5) "Qualities requisite to refractory materials and methods of testing and of physical and chemical control," by R. V. Widemann; (6) "Theoretical and experimental researches on the crushing of refractory products under load in heat," by Pierre Bremond; (7) "Present evolution and recent progress of the industry of special refractory products in France," by Daniel Petit; and (8) "Carbon, refractory material, and anti-acid," by René Maire. M.V.C.

Trends in design of large, high-pressure, high-temperature boiler units. F. H. ROSENCRANTS. Presented at Midwest Power Engineering Conference, Chicago, April, 1936; reviewed in *Combustion*, **7** [11] 16–22 (1936). H.E.S.

William H. Bloor. ANON. *Bull. Amer. Ceram. Soc.*, **16** [1] 25–31 (1937).

BOOKS AND BULLETINS

American Society for Testing Materials Standards, 1936: I, Metals; II, Nonmetallic Materials. American Society for Testing Materials, Philadelphia, Pa. Price to nonmembers $7.50 per part, both parts for $14.00. Part I has more than 900 pp. and contains 181 standards. Part II has more than 1500 pp. and contains 335 standard specifications, test methods, and definitions covering cement, gypsum, concrete, refractories, coal, etc. R.A.HEINDL

Dechema Engineering Materials Reports. E. RABALD. Verlag Chemie G.m.b.H., Berlin. Reviewed in *Brit. Clayworker*, **45** [536] 284 (1936).—R. shows clearly the importance given in Germany to engineering materials. This is due partly to the scarcity of raw materials in that country; on the other hand, through such concentrated research work, particularly far-reaching progress was attained which was not reached in other countries. This is especially the case in ceramic engineering materials which made great progress in Germany. Just now, when efforts are being made to make up for lost time, this report on progress is of considerable interest. R.A.H.

Mining and grinding methods and costs at the Clay City Pipe Co. clay mine, Uhrichsville, Ohio. E. J. LINTNER. *U. S. Bur. Mines Information Circ.*, No. 6913, 16 pp. Free. L. describes procedures and equipment at an efficiently managed clay mine in the country's leading ceramic district. R.A.HEINDL

Physical Chemistry of Boiler Scale Formation and Its Prevention (Die physikalische Chemie der Kesselsteinbildung und ihre Verhütung). R. STUMPER. Ferdinand Enke, Stuttgart, 1933. 74 pp., 18 illustrations. Price 5.30 Rm. Reviewed in *Jour. Phys. Chem.*, **38** [2] 245 (1934). S.I.P.

Review of literature on effects of breathing dusts with special reference to silicosis: III-A. D. HARRINGTON AND SARA J. DAVENPORT. *U. S. Bur. Mines Information Circ.*, No. 6857 (Oct., 1935). 56 pp. Free. Economic and legal aspects of dust diseases in industry are presented. **III-B.** *Ibid.*, No. 6892 (Aug., 1936). 68 pp. Free. This concludes the series issued by the Bureau presenting abstracts of literature connected with the subject of silicosis. For Part **II-B** see *Ceram. Abs.*, **15** [6] 195 (1936). R. A. HEINDL

Seasonal fluctuations in the pottery industry and their influence on costs. KURT HEINRICH MACHEMER. Published by Konrad Triltsch, Würzburg, Germany. Price 3 Rm. Reviewed in *Brit. Clayworker*, **45** [536] 284–85 (1936).—This study on the influence of seasonal fluctuations in the pottery industry on costs is the result of the "unfavorable economic development" in Germany which has placed before the pottery industry increasingly difficult tasks. R.A.H.

PATENTS

Glazed ceramic ware and method of making. G. R. POLE (Tennessee Valley Authority). U. S. 2,063,953, Dec. 15, 1936 (Feb. 27, 1936). Process for making glazed ceramic ware comprises burning a phosphate reduction furnace gas to form a gaseous mixture containing phosphorous pentoxide, and contacting a glazed ceramic ware with the gaseous mixture containing phosphorous pentoxide, while maintaining the ware at a glazing temperature.

Process of improving glass glazes and enamels. DEUTSCHE TAFELGLAS A.-G. (Detag). Brit. 454,189, Oct. 7, 1936 (Nov. 5, 1934).

OFFICIAL PERSONNEL OF DIVISIONS, 1936 to 1937

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